
ia
instituto de astrofísica
e ciências do espaço
Institute of Astrophysics
and Space Sciences
2022 Activity Report

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e ciências do espaço

COFINANCIAMENTO / COFINANCING

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Unit Overview

The **Instituto de Astrofísica e Ciências do Espaço** (**IA**) is a research infrastructure with a national dimension, embodying a bold vision for the development of Astronomy, Astrophysics and Space Sciences in Portugal. It is the largest research unit of this area in the country, being responsible for the majority of the national productivity in international ISI journals in the area of Space Sciences — one of the scientific areas with the highest relative impact factor and highest average number of citations per article for Portugal. IA has a demonstrated ability to drive major astronomical projects, at all development levels: scientific and technical definition, instrument concept and design, construction and commissioning, and scientific exploitation.

The mission of IA is to foster research with the highest impact in the field of astrophysics and space sciences and to support teaching and training of young researchers and students in close collaboration with the Universities of Lisbon and Porto, and from June 2021, in Coimbra. Indeed, IA has now grown with the creation of a new pole at the University of Coimbra, with headquarters at the Observatório Geofísico e Astronómico of the University of Coimbra (OGAUC), of the Science and Technology Faculty of the University of Coimbra (FCTUC), which reveals the national impact of the IA. It also aims to promote wide-ranging science communication activities that enhance public understanding of the Universe and our place in it, as well as awareness of the importance of research in this field.

Our vision is to achieve international leadership in key areas of astrophysics and space sciences, taking full advantage and realising the potential created by the national membership of the European Space Agency (ESA) and the European Southern Observatory (ESO) and the Square Kilometre Array Observatory (SKAO). This is done through state-of-the-art research, enabled by our leading participation in strategic international ground and space-based projects and missions.

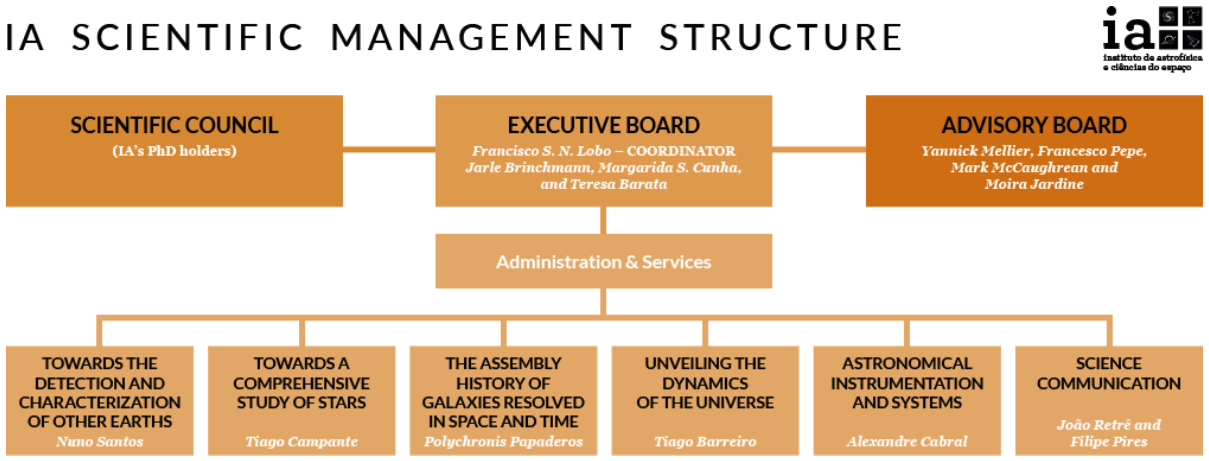
As in the previous year, the first two months of 2022 were marked by the continued COVID-19 pandemic which deeply influenced the activity of IA. However, the easing of COVID restrictions implied the gradual return to in-person activities. During 2022 the IA team continued to produce high-impact scientific results, as clearly seen in our annual report below, even though preparatory activities, such as for scientific instruments, were delayed. Much effort was invested in the strengthening of new synergies within the three nodes, which have provided a broadened perspective and depth of skills that has allowed IA to significantly extend our reach on the international stage. We also note the recent establishment of a Diversity and Inclusion Group to provide added support and guidance to the growing team at IA.

The following pages provide an overview of IA's activities during 2022. In particular, note the involvement of IA in the ESA and ESO projects, originally triggered by specific science cases, which has led to a strengthening of the inter-group collaborations and development of new synergies within IA. We acknowledge and appreciate the personal efforts from researchers, students and support personnel that kept IA going during the previous COVID-19 pandemic years and pay homage to our team for their resilience in the face of the specially difficult conditions.

Francisco S.N. Lobo, Jarle Brinchmann, Margarida S. Cunha, Teresa Barata
IA Executive Board

IA Management

The Executive Board is composed of 2 members from the Porto node (Jarle Brinchmann and Margarida S. Cunha), 1 member from the Lisbon node (Francisco S.N. Lobo) and 1 member of the Coimbra node (Teresa Barata), with Francisco S.N. Lobo as the coordinator of the research unit. On the 9th June 2022, the Scientific Council voted to replace Noemi Frusciante (Lisbon node), who took on a position at the University of Naples, with Teresa Barata.



During 2022, the EB continued having regular weekly meetings to coordinate the scientific and management activities of the IA strategic plan. Every other week these meetings also include group leaders, including the Science Communication Group. Contacts with the management institutions were also done whenever necessary.

IA-ON 9

Due to the pandemic restrictions the **9th Internal workshop** (**IA-ON 9**) took place virtually on the 11th of November.

The IA-ON 9 assembled most of the team, with an attendance of 98 participants among researchers, students, and support personnel. The highlights of the year were shared and discussed with the whole team. In 2022, the focus was given to the key scientific questions to be addressed by the scientific groups and the future strategy of the IA. The fully online IA-ON9 was also carefully organised to build on to the following Internal workshop IA-ON 10, to take place in January 2023, which is meant to fully address the external Advisory Board visit and the pending FCT evaluation of the Research Units.

The IA team (2022)

Towards the detection and characterization of other Earths (Planets Group)

Researchers (PhDs)
Alberto Negrão
Elisa Delgado Mena *
João N. T. Gomes da Silva (left 30 April)
João P. Faria
Jorge H. C. Martins
José E. O. Silva (joined 01 June) (left 31 August)
L. Filipe Pereira * (joined 07 February)
Nuno Peixinho *
Nuno C. Santos
Olivier D. S. Demangeon
Pedro Machado
Pedro Pina *
Pedro Figueira
Pedro B. Lacerda (joined 28 January)
Pedro T. P. Viana
Sérgio A. G. Sousa *
Susana C. C. Barros
Tiago J. L. C. E. Campante *
Vardan Zh. Adibekyan *

Others
Abderahmane Soubkiou (PhD student) (left 31 December)
Alexandros Antoniadis Karnavas * (PhD student)
Ana Rita Costa Silva (PhD student)
André Miguel A. C. V. Silva * (PhD student)
António M. B. Correia (MSc) (joined 21 September)
Bárbara M. T. B. Soares (PhD student)
Constança T. Freire (MSc)
Daniela C. Espadinha (PhD student)
Diogo Quirino (MSc) (left 11 July)
Eduardo A. S. Cristo (PhD student)
Francisco Brasil (PhD student)
Joana R. A. Teixeira (MSc) (joined 01 October)
João André B. Dias (MSc) (left 14 January)
João André B. Dias (PhD student) (joined 01 October)
João D. R. Camacho (PhD student) (left 13 June)
José E. O. Silva (PhD student) (left 11 May)
José Lino (MSc) (joined 15 September)
José Luís F. Ribeiro (PhD student)
José M. L. Amoreira (MSc) (joined 01 March)
José Rodrigues (PhD student)
Miguel C. Ralha (MSc)
Nuno M. Rosário (PhD student)
Rafael Rianço-Silva (MSc) (joined 01 June)
Tomás de Azevedo Silva (PhD student)
Vasco Silva (MSc)

Towards a comprehensive study of stars (Stars Group)

Researchers (PhDs)
Ângela R. G. Santos
Anna Morozova
Daniel F. M. Folha
Diego Bossini
Elisa Delgado Mena *
João J. G. Lima
João L. Yun

Others
Alexandros Antoniadis Karnavas * (PhD student)
Ana F. S. Barros (PhD (LIACC)) (joined 14 March)
Andreas W. Neitzel (MSc) (left 29 September)
Andreas W. Neitzel (PhD student) (joined 30 September)
Anselmo J. G. Falorca (BII) (joined 01 March) (left 30 April)
Anselmo J. G. Falorca (MSc) (joined 29 September)
Bárbara S. Oliveira (PEEC) (joined 01 March) (left 01 August)

Jorge Filipe Gameiro
L. Filipe Pereira * (joined 07 February)
Mário J. P. F. G. Monteiro
M. S. Nanda Kumar (left 14 March)
Margarida S. Cunha
Maria Teresa Barata
Maria Teresa V. T. Lago
Morgan Deal (left 31 August)
Nuno Peixinho *
Pedro Pina *
Pedro M. Palmeirim (left 31 October)
Pedro P. Avelino *
Ricardo Jorge Gafeira
Rui Agostinho *
Sérgio A. G. Sousa *
Sara J. Carvalho (joined 28 January)
Tiago J. L. C. E. Campante *
Vítor M. M. Costa
Vardan Zh. Adibekyan

Carlos M. F. António (MSc) (joined 30 September)
Davi C. Nascimento (MSc) (joined 01 November)
Eva L. Silva (MSc)
Gabriela Lapa (MSc) (joined 15 September)
Grégoire Francisco (PhD student) (joined 01 November)
Inês M. Rolo (MSc) (joined 15 September)
Joana C. S. Leite (MSc) (joined 15 September)
Joana P. M. F. Pereira (MSc) (joined 01 September)
João M. A. Custódio (PEEC) (joined 01 March) (left 30 April)
Margarida Santiago (MSc) (left 29 September)
Maria Inês M. F. S. Ferreira (BII) (joined 01 March) (left 30 April)
Maria Inês M. F. S. Ferreira (MSc) (joined 15 September)
Miguel T. Clara (PhD student)
Nuno A. M. Moedas (PhD student)
Paulina M. Zaworska (PhD student)
Pedro M. Martins (MSc) (left 03 March)
Slava L. L. Bourgeois (PhD student)
Tatiana S. S. Mendes (BII) (joined 01 March) (left 30 April)
Thibault Boulet (PhD student)
Yuri C. Damasceno (PEEC) (joined 01 March) (left 01 August)

The assembly history of galaxies resolved in space and time (Galaxies Group)

Researchers (PhDs)

Ana S. Paulino Afonso
Andrew J. Humphrey (left 22 July)
Bruno Arsioli (joined 01 November)
Catarina Lobo
Cirino Pappalardo
Israel Matute
Jarle Brinchmann
Jean Michel Gomes
José Afonso
Patricio Lagos
Polychronis Papaderos
Rui Agostinho *
Stergios Amarantidis (left 18 April)
Tom C. Scott

Others

Abhishek Chougule (PhD student)
Afonso M. A. Vale (BI) (joined 01 October)
Bruno B. Cerqueira (BI) (joined 01 October)
Daniel A. D. Vaz (PhD student)
Davi D. Barbosa (PhD student)
Duarte M. Santos (MSc)
Eleanor L. Worrell (PhD student) (joined 21 February)
Henrique B. Miranda (PhD student) (joined 03 February)
Mara Jacinto (PhD student) (joined 01 January)
Nuno A. R. Carvalho (MSc) (left 09 December)
Pedro A. A. Nogueira (PEEC) (left 05 August)
Pedro Alexandre C. Cunha (PhD student)
Pedro M. Martins (PhD student) (joined 01 September)
Rodrigo A. Carvajal Pizarro (PhD student)
Sandy G. Morais (PhD student)

Unveiling the dynamics of the Universe (Cosmology Group)

Researchers (PhDs)
Alberto Rozas-Fernández (left 30 June)
Andrew R. Liddle
António C. da Silva
Bruno J. Barros (joined 15 December)
Carlos J. A. P. Martins
Claudio Llinares
Francisco S. N. Lobo
Francisco T. O. Cabral (joined 01 February) (left 31 July)
Giuseppe Fanizza
Ismael Tereno
Ivan Rybak (left 14 October)
José Carlos Fonseca
José Pedro Mimoso
Lara G. Sousa
Marina Cortês
Nelson J. Nunes
Noemi Frusciante (left 31 May)
Paulo Crawford
Paulo M. Sá
Paulo Maurício de Carvalho
Pedro P. Avelino *
Tiago Barreiro

Others
Adrian H. M. Cabral (PEEC) (joined 01 February) (left 30 September)
Alessio Suriano (Erasmus Traineeships) (joined 16 May) (left 15 July)
Ana C. O. Leite (PhD student)
Ana Sofia Carvalho (PhD student)
Catarina M. J. Marques (PhD student) (joined 01 October)
Daniela Cordeiro (MSc) (joined 23 November)
David Grüber (PhD student)
David M. Oliveira (PhD student) (joined 25 February)
Diogo M. L. Castelão (PhD student)
Filipe Correia (MSc) (left 31 December)
Francisco C. N. Q. Pimenta (MSc)
Hilberto M. R. da Silva (PhD student) (left 30 September)
Inês S. Albuquerque (PhD student)
Ismael Ayuso (PhD student) (left 18 July)
João D. F. Dias (PhD student)
Jorge M. S. B. F. Lopes (BSc Project) (joined 14 March) (left 10 June)
José Ferreira (MSc)
José Ricardo Correia (PhD student) (left 13 May)
Luís Atayde (MSc) (joined 01 October) (left 30 March)
Luís Atayde (PhD student) (joined 01 October)
Luís F. D. Silva (MSc) (joined 23 November)
Maria Alexandra Gonçalves (MSC) (left 31 December)
Miguel A. S. Pinto (MSc)
Miguel J. P. C. Conceição (PhD student)
Renata S. Trintin (PhD student) (left 31 March)
Rui P. L. Azevedo (PhD student) (left 23 June)
Samuel R. P. Veiga (MSc) (joined 01 February) (left 30 September)
Sara N. F. de Nóbrega (MSc) (left 30 March)
Sergei Mukovnikov (PhD student)
Tiago Barreiro Gonçalves (PhD student)
Vitor da Fonseca (PhD student)

Astronomical Instrumentation and Systems (Instrumentation Group)

Researchers (PhDs)
Alexandre Cabral
Bachar Wehbe
David Castro Alves (joined 01 February)
Elena Duarte

Others
André Miguel A. C. V. Silva * (PhD student)
Andreia Domingos (BSc)
António Oliveira
Catarina Chaves (MSc) (joined 01 September)

João Dinis

João Coelho

José M. Rebordão

Manuel Abreu

Nuno Peixinho *

Raul Cerveira Lima *

Sérgio A. G. Sousa *

Cédric P. Pereira (PhD student)

Guilherme R. J. Roque (MSc) (left 25 March)

Inês Meira Leite (PhD student)

Joel Filho (PhD student) (joined 06 April)

Manuel Monteiro

Nuno Miguel Gonçalves (PhD student)

Pedro Santos (left 30 September)

Renato P. Alegria (MSc) (left 01 April)

Sílvia Costa (BSc)

Science Communication Group

Staff

Adriana Silva (joined 23 May)

Catarina Leote

Elsa M. P. S. Moreira

Filipe A. L. Pires

Ilídio André P. M. Costa

João Retrê

José Manuel C. Dantas

Paulo J. T. Pereira

Ricardo S. S. C. Reis

Sérgio Pereira

Tania F. S. Cunha

Researchers (PhDs)

Ilídio André P. M. Costa

Joana Marques (joined 18 February)

Interface to Science (Support to Science Activities)

Argentina Pereira

Carlos Santos

Elsa Marta Silva

Joana Bateira (joined 1 March)

Sandra Homem

Researchers that work in more than one group are marked with (*).

Research Projects/Programmes

During 2022, a number of funded projects were on-going at IA, providing most of the funds available for research, including outreach activities.

Projects focused on scientific activities

The research projects that in 2022 were supported by national and European funds are:

(i) Projects funded by the European Commission (EC):

- SKilled, Innovative & Entrepreneurial Scientists (SKIES) (GA Nº 101006212)
  PI: Jarle Brinchmann
  [start date: 01 March 2021 – end date: 31 August 2022]

- Revealing the Milky Way with Gaia (MW-GAIA) (COST ACTION CA18104)
  PI: Vardan Adibekyan & Nuno Santos
  [start date: 14 March 2019 – end date: 13 March 2023]

- Space Weather Awareness Training Network (SWATNet) (H2020-MSCA-ITN-955620)
  PI:Teresa Barata
  [start date: 1 March 2021 – end date: 28 February 2024

- Multifrequency and Machine Learning methods to Search for Early Super Massive Black Holes (ML-SMBH) (HORIZON-MSCA-2021-PF-01-101066981)
  PI: Bruno Arsioli
  [start date: 1 December 2022 – end date: 30 November 2024]

- FInding ExoeaRths: tackling the ChallengEs of stellar activity (FIERCE) (GAP-101052347, ERC-2021-ADG)
  PI: Nuno Santos
  [start date: 1 October 2022 – end date: 30 September 2027]

(ii) Research projects funded by Fundação para a Ciência e a Tecnologia (FCT):

- Characterizing the smallest planet hosts (IF/00849/2015/CP1276/CT0003)
  PI: Elisa Delgado Mena
  [start date: 1 January 2017 – end date: 31 March 2022]

- Zoom-In ON hIgh-mass Star forMation (IF/00956/2015/CP1273/CT0002)
  PI: Nanda Kumar
  [start date: 15 December 2016 – end date: 14 March 2022]

- Probing the Physics of the Dark Universe with Euclid (IF/01135/2015)
  PI: António da Silva
  [start date: 3 October 2016 – end date: 2 January 2022]

- Modified Gravity impact on Cosmology and Astroparticles (MGiCAP)
  (CERN/FIS-PAR/0037/2019)
  PI: Francisco Lobo
  [start date: 1 September 2020 – end date: 31 August 2022]

- Probing cosmic strings and other topological defects with gravitational waves (Gwstrings)
  (POCI-01-0145-FEDER-031938 & PTDC/FIS-PAR/31938/2017)
  PI: Lara Sousa
  [start date: 15 October 2018 – end date: 14 October 2022]

- Planets – Towards Understanding their General circulation Atmospheres (P-TUGA)
  (PTDC/FIS-AST/29942/2017)
  PI: Pedro Machado
  [start date: 3 September 2018 – end date: 2 June 2022]

- Identify the Earliest Supermassive Black Holes with ALMA (IdEaS with ALMA)
  (PTDC/FIS-AST/29245)
  PI: José Afonso
  [start date: 3 September 2018 – end date: 2 September 2022]

- Spacetime ripples in the dark gravitational Universe (DarkRipple)
  (PTDC/FIS-OUT/29048/2017)
  PI: Francisco Lobo
  [start date: 1 September 2018 – end date: 31 August 2022]

- a Generation of Earth-ANalogs Exploration Spectrographs (G.EANES)
  (POCI-01-0145-FEDER-032113 & PTDC/FIS-AST/32113/2017
  PI: Nuno Santos
  [start date: 1 August 2018 – end date: 31 July 2022]

- Cosmology and Fundamental Physics with ESPRESSO (CosmoESPRESSO)
  (POCI-01-0145-FEDER-028987 & PTDC/FIS-AST/28987/2017
  PI: Carlos Martins
  [start date: 1 June 2018 – end date: 31 May 2022]

- Exploring exoPlanets wIth CHEOPS (EPIC)
  (POCI-01-0145-FEDER-028953 & PTDC/FIS-AST/28953/2017)
  PI: Sérgio Sousa
  [start date: 1 June 2018 – end date: 31 May 2022]

- Breaking through outstanding problems in stellar evolution with ultra-precise space-based photometry (BreakStarS) (POCI-01-0145-FEDER-030389 & PTDC/FIS-AST/30389/2017)
  PI: Margarida Cunha
  [start date: 1 May 2018 – end date: 30 April 2022]

- Dark matter and metals in galaxies (DarkMAGE) (PTDC/FIS-AST/4862/2020)
  PI: Jarle Brinchmann
  [start date: 1 September 2021 – end date: 31 August 2024]

- BEYond Lamba (BEYLA) (PTDC/FIS-AST/0054/2021)
  PI: Noemia Frusciante
  [start date: 1 January – end date: 31 December 2024]

- Stellar Activity Modelling for exoplanet detection (SAM) (EXPL/FIS-AST/0615/2021)
  PI: João Faria
  [start date: 1 January 2022 – end date: 31 December 2022]

- Finding Lyman-alpha emitters through machine learning (FLAEMING) (EXPL/FIS-AST/1085/2021)
  PI: Ana Paulino-Afonso
  [start date: 1 January 2022 – end date: 31 August 2023]

- Portuguese Regional Ionosphere ModEl (PRIME) (EXPL/CTA-MET/0677/2021)
  PI: Anna Morozova
  [start date: 1 January 2022 – end date: 31 November 2023]

- Abordagens de aprendizagem automática para a cosmologia com enxames de galáxias a partir da missão Euclid (ML_Clusters) (EXPL/FIS-AST/1368/2021)
  PI: António da Silva
  [start date: 1 January 2022 – end date: 30 December 2023]

- Bioscosmologia: O nascimento de uma nova ciência (Biocosm) (EXPL/FIS-AST/1418/2021)
  PI: Andrew Liddle
  [start date: 1 January 2022 – end date: 30 June 2023]

(iii) Infrastructure funded projects (FCT):

- R&D Unit 2020-2023 Financing: Instituto de Astrofísica e Ciências do Espaço (UIDB/04434/2020 & UIDP/04434/2020)
  PI: Francisco Lobo
  [start date: 1 January 2020 – end date: 31 December 2023]

(iv) Cooperation projects funded by Gabinete de Relações Internacionais da Ciência e do Ensino Superior (FCT) and by Conselho de Reitores das Universidades Portuguesas

- DevelOpment of PaloPknowLEdge in Radioasteronomy (DOPPLER) (Aga Khan Development Network/FCT)
  PI: Nuno Peixinho
  [start date: 1 January 2018 – end date: 30 August 2022]

- Strategic partnership in astrophysics Portugal-Brazil: the connection between black holes and galaxies using powerful new instrumentation and theoretical insights (Cooperação Científica e Tecnológica FCT/CAPES)
  PI: Andrew Humphrey / Jean Michel Gomes
  [start date: 1 May 2018 – end date: 31 December 2022]

- Evolution of realistic cosmic strings and superstrings (Convénio FCT/CNRS)
  PI: Carlos Martins
  [start date: 1 January 2021 – end date: 31 December 2022]

- Black Hole mergers as probes of Large Scale Structure (Bilateral Research Programme 2022 - PARSUK)
  PI: José Carlos Fonseca
  [start date: 1 September 2022 – end date: 31 December 2022]

(vi) Other projects

- Participation to CHEOPS Science Operations Centre (SOC)
  PI: Nuno Santos
  [start date: 31 October 2013 – end date: 31 October 2023]

- PLATO OGSE and PDC Phase B (ESA Contract No. 4000133026)
  PI: Nuno Santos
  [start date: 1 January 2018 – end date: 31 December 2022]

- PLATO OGSE Collimator #3 (ESA Contract No. 4000137577)
  PI: Manuel Abreu
  [start date: 1 March 2022 – end date: 31 August 2022]

- ARIEL OGSE and Baffle Development (ESA Contract No. 4000138111)
  PI: Manuel Abreu
  [start date: 1 June 2020 – end date: 31 December 2022]

- On-board Metrology for Athena (ESA Contract No. 4000131014/20/NL/HB/gg)
  PI: Manuel Abreu

[start date: 19 June 2020 – end date: 1 October 2022]

- MWWM: Mars Wind Wave Mapping (ESA RFP/3-17570/22/ES/CM)
  PI: Pedro Machado
  [start date: 6 June 2022 – end date: 5 June 2023]

- Moons AIT: Partnership for the MOONS Consortium for the Construction of a Multi-Object Optical and Near-infrared Spectrometer for the VLT (ESO-VLT-MOU-MON-14620-0001)
  PI: Alexandre Cabral
  [start date: 27 November 2020 – end date: 26 May 2023]

- Space Weather and GNSS monitoring services for Air Navigation (SWAIR) (ARTES IAP Demonstrador Project)
  PI: Teresa Barata
  [start date: 1 March 2018 – end date: 31 August 2022]

- Coimbra Solar Database (SCOSTEP/PRESTO Grants for year 2021, Applications of Database Proposals)
  PI: Teresa Barata
  [start date: 1 December 2021 – end date: 31 December 2022]

- Space Weather (SWE) Products for Southern Europe - Phase 1 (PROSE) (ESA)
  PI: Anna Morozova
  [start date: 23 June 2022 – end date: 30 October 2023]

- ERAACA: Elaboração da Estratégia Regional de Adaptação às Alterações Climáticas do Alentejo (CPS02/2022)
  PI: Pedro Machado
  [start date: 16 March 2022 – end date: 15 June 2023]

Projects focused on communication and outreach

During 2022 there were several funded projects in IA:

- AstroCamp 2022
  PI: Carlos Martins
  [start date: 1 january 2022 – end date: 1 December 2022]

- Ocupação Científica dos Jovens nas Férias 2022
  PI: Carlos Martins
  [start date: 1 January 2022 – end date: 31 December 2022]

- Formação ESERO
  PI: Filipe Pires/Ilídio Costa

[start date: 1 January 2022 – end date: 31 December 2022]

- Renewing the solar system exhibition – Europlanet Society
  PI: João Retré
  [start date: 1 January 2020 – end date: 31 December 2023]

- Light Fingerprints - Europlanet Society
  PI: Nuno Santos
  [start date: 1 january 2021 – end date: 31 December 2022]

- SDSS block grants for Plate distribution
  PI: Filipe Pires/Ilídio Costa
  [start date: 1 january 2021 – end date: 31 December 2022]

- Capacitação dos Centros de Ciência Viva (NORTE-09-5864-FSE-000027)
  PI: Filipe Pires
  [start date: 1 April 2021 – end date: 31 March 2023]

- From SKA to the World (FSKAW) (IAU)
  PI: João Retrê
  [start date: 1 April 2022 – end date: 31 December 2022]

- Abordagem STEM e a sua influência nas aprendizagens de Física, interesse e motivação (GoSTEM) (PTDC/CED-EDG/31480/2017)
  PI: Rui Agostinho
  [start date: 1 March 2019 – end date: 28 February 2023]

Scientific Output and Activities

The overall output of IA in **2022** was (see appendix **Scientific Output** for details)

213
Papers in refereed journals

23
Papers in books and proceedings

141
Communications in international meetings

61
Communications in national meetings

26
Seminars in other institutions

29
Seminars organized at IA

246
Public outreach talks

14
MSc thesis completed

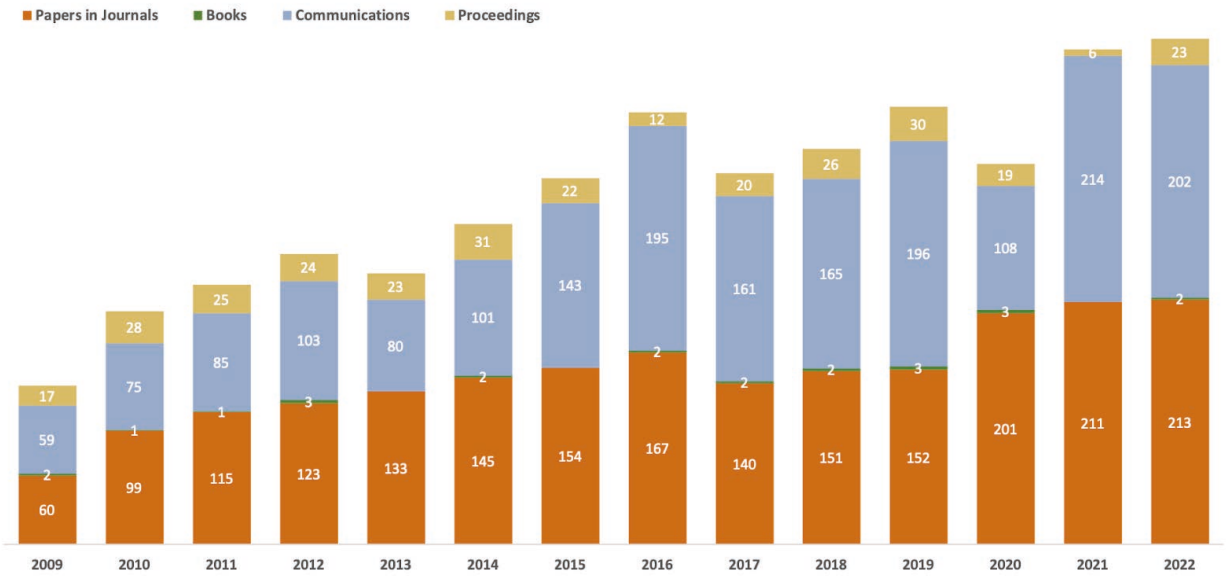
4
PhD thesis completed

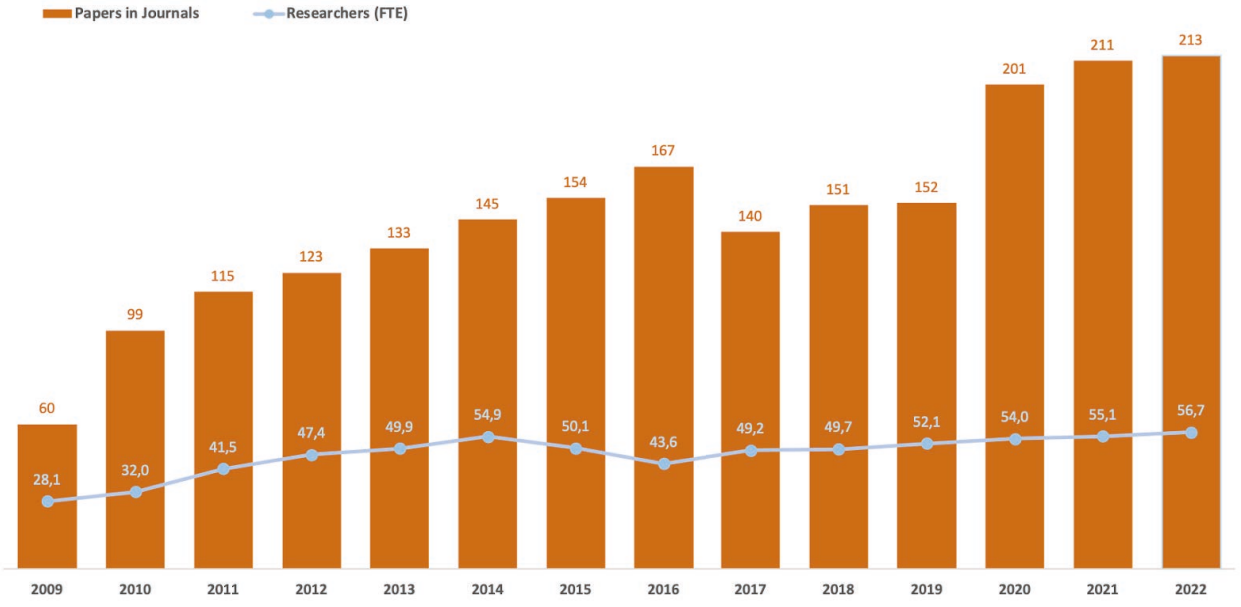
17
Observing runs

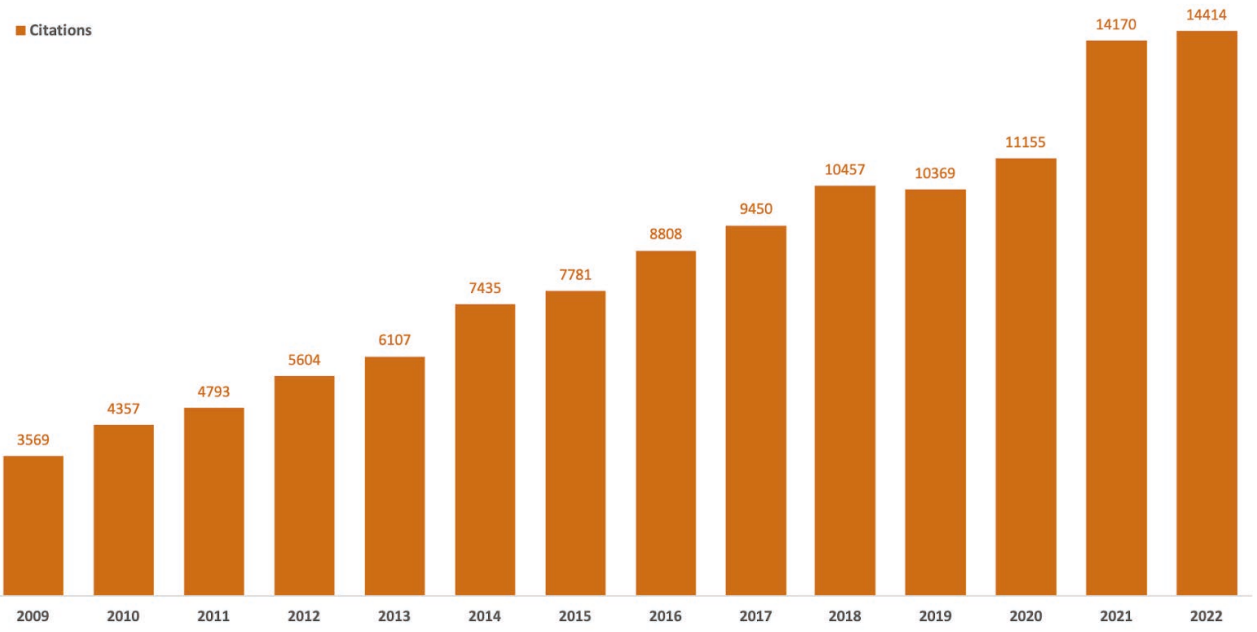
6
Organization of conferences

7
Reports

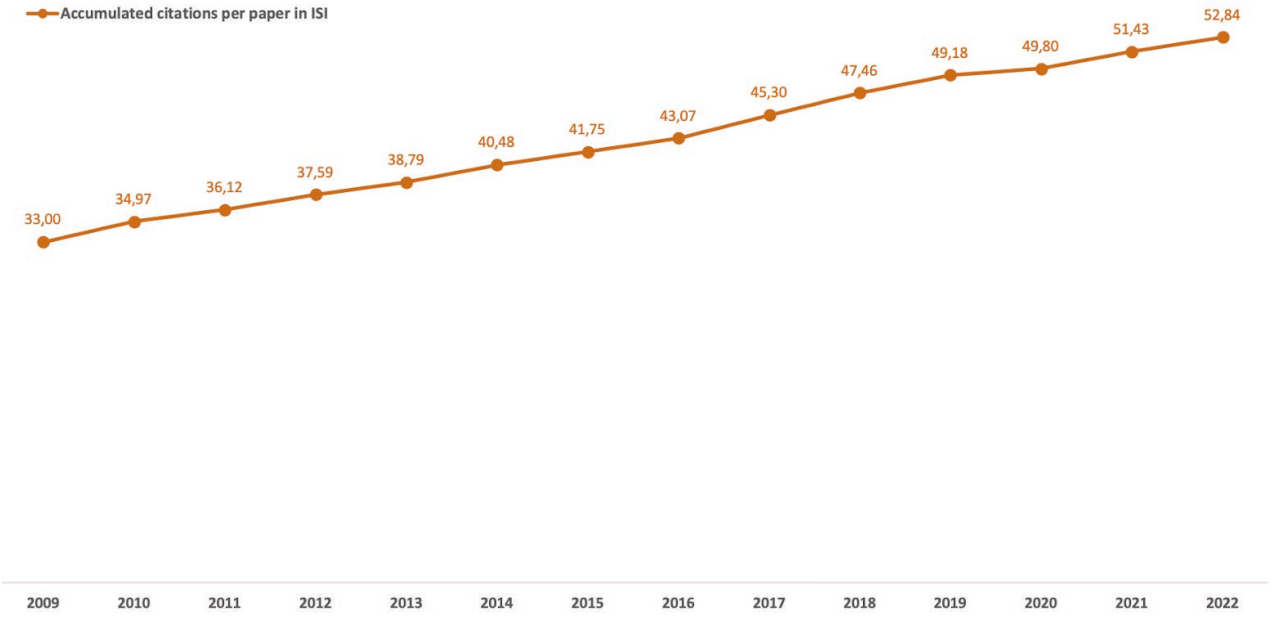
The figures below illustrate the institute's productivity during the past year. There is a clear and natural relation between the number of researchers and the number of papers in journals subject, understandably, to a small shift in time. The figures show a continuation of the increase in the number of publications and communications, which is a strong indication for the strong activity of the Institute. The number of citations also maintains an increasing trend which is not simply justified by an increase in the numbers or articles. Indeed, the figures show that the accumulated impact continues to grow.







The number of citations obtained in a given year for all the IA articles published since 1990 up to that year.



The accumulated impact in a given year is measured as the ratio between the sum of the number of citations up to that year since 1990 and the number of articles in the same period.

Report from the Group

Towards the detection and characterisation of other Earths

Activities of the team focused around the two major areas: Exoplanets and Solar System research. Exoplanet research has been mostly centred in the Porto node, while Solar System research is divided in planet atmospheres (centred in Lisbon) and the study of minor bodies Solar System and planetary surfaces (centred in Coimbra). Active collaborations exist between the three nodes, namely in the study of planetary atmospheres (Porto-Lisbon) and the study of solar system exospheres (Lisbon-Coimbra).

On the **exoplanet side**, the team is focused on tackling high impact questions such as: are there other Earths orbiting other Suns and how can we detect them? What is the composition of exoplanets and of their atmospheres, and what is their internal structure? How diverse are planetary systems? How can we tackle the challenges of stellar “noise” in exoplanet research? How do their properties (composition, architecture, …) relate with those from their host stars and what clues do these provide about the planet formation and evolution process?

To answer these questions, the team focuses its activities on:

1. the search and characterization of exoplanets using state-of-the-art radial velocity data, including the detection and mass measurement of planets previously detected by the transit method (e.g. with missions such as TESS);
2. the study of exoplanet atmospheres using broad-band photometry, high-resolution spectroscopy and model atmospheres.
3. the study of astrophysical sources of noise for the detection and characterization of planets as well as methods to correct/model them and obtain more precise radial velocities;
4. the study of planet-host stars as a way to characterize planets as well as their properties and formation processes, as well as the statistical study of planet properties as well as the relation with the properties of the host stars.

A significant part of this research was done in the context of our top-level participation as consortium members in ESO's ESPRESSO project (started operations in 2018) and ESA's CHEOPS mission (launched in late 2019, with operations recently extended up to the end of 2026). Given our key roles and contributions in the project phase, we have been exploiting our privileged access to the definition of the science programs of ESPRESSO and CHEOPS, as well as the analysis of the obtained data. Several high impact results were published based on these data (see below), and several others are in preparation.

Furthermore, making use of the know-how that was (and is) built from these projects, we are now preparing for the exploitation of data from the new NIRPS spectrograph (@ESO's 3.6m), that will start the operations in April 2023. Our high-level participation in these projects reinforces the existing strategy and allows the team to be in the forefront of exoplanet detection and characterization.

In this context, we are already preparing for the science opportunities raised by future projects and missions such as the HIRES@ESO's ELT spectrograph (2030, approved for construction by ESO in December 2021)

as well as the PLATO and ARIEL missions (ESA - 2026 and 2029, respectively). For all of those, we are responsible for scientific tasks as well as part of the data reduction/analysis pipelines.

A final highlight to mention is the ERC Advanced Grant that was offered to one of the team members. The approved project proposes to build a new telescope (PoET - http://poet.iastro.pt) to tackle the problems of stellar signals (or "noise") in the detection and characterization of other Earths. This project is fully in line with (and will potentiate) the science goals mentioned above.

On the **Solar System** side, most research focused on the exploration of new avenues in the study of Solar System atmospheres, namely to tackle questions such as: what do we know about the dynamics and chemistry of solar system planet atmospheres? This aspect has clear links with the study of exoplanet atmospheres that are also being exploited. Of relevance here is the leadership in the WG responsible for the study of these synergies within the ARIEL consortium

Within this context, the team continued different studies of the atmospheres of Venus, Mars, Saturn, and Jupiter. We can highlight here the use of both ground and space-based observations to perform dynamical studies based on cloud tracking techniques (UV and IR) and the detection and characterization of atmospheric waves.

Synergies with the study of Minor bodies and the Solar System history are also being explored addressing questions like: what does the dynamics and composition of minor bodies tell us about the formation of the Solar System? And what about the cratering history?

Scientific Highlights for 2022

In 2022, a total of 7 IA Press-releases were published announcing scientific or science-related results with a leading participation of the team. Of these, 2 were also ESO Press Releases and 1 was an ESA Press Release. Most of them were done in an international context. The list of highlights below is based on some of these.

Detection of Barium in exoplanet atmospheres: the heaviest element ever detected

A team, led by an Instituto de Astrofísica e Ciências do Espaço researcher and PhD student Tomás Azevedo Silva, discovered barium in the atmosphere of ultra-hot gas giants WASP-76 b and WASP-121 b. This discovery represents the detection of the heaviest element ever detected in the atmosphere of an exoplanet.

For this result, the team used the ESPRESSO instrument on ESO’s VLT to analyse and study the transmission spectrum of WASP-76 b and WASP-121 b. These measurements are done during the transit of the planet in front of its star, allowing to analyse the light that crosses the planet's atmosphere. This made it possible to clearly detect several elements, including barium.

WASP-76 b and WASP-121 b are no ordinary exoplanets: both are ultra-hot Jupiters as they are comparable in size to Jupiter. Being very close to their host stars, they have extremely high surface temperatures above 1000°C.

The puzzling and counterintuitive aspect of this discovery is: why is there such a heavy element in the upper layers of the atmosphere of these planets? The team was surprised to find barium, which is 2.5 times heavier than iron, in the upper atmospheres of these planets. Given the high gravity of the planets, we would expect heavy elements like barium to quickly fall into the lower layers of the atmosphere.

This result thus defies the models of planet atmospheres, bringing new light into the physical processes happening on them.

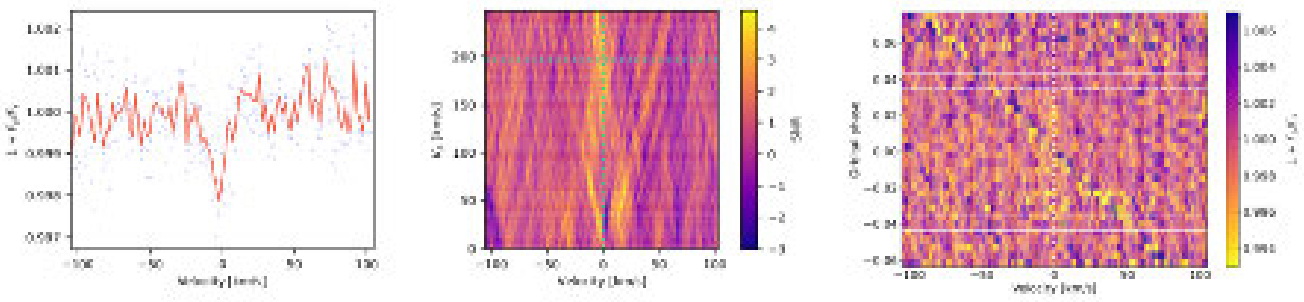


Figure: Plots illustrating the detection of Barium in the atmosphere of WASP-76b. From Azevedo Silva et al. 2022 (A&A 666, L10).

Unveiling a new population of super-Mercuries

In two different papers published in 2022, the team unveiled the presence of three new members of a new population of "super-Mercury" like planets.

The planet Mercury, in the Solar System, has a relatively larger core and relatively smaller mantle than the other planets, but we don't know why. Some possible explanations involve a giant impact which removed part of the planet's mantle or, because of its high temperature, part of Mercury's mantle could have evaporated. Surprisingly, other exoplanets with similar characteristics, called super-mercuries, were only recently found around other stars.

In a first study, led by Tomás Azevedo Silva (PhD student of IA - Azevedo Silva et al. 2022, A&A 657, A68), the team announced the discovery of a super-mercury orbiting the star HD137496 b. With an interior modeling analysis, and based on the known radius and mass of the planet, they found that the planet is composed mainly of iron, with the core representing over 70% of the planet's mass (Mcore / Mtotal = 0.73–0.12+0.11). The system also has a second planet in a longer period orbit: an eccentric long period gas giant.

In a second study, using data from the ESPRESSO spectrograph, a team led by IA researcher Susana Barros discovered a system with two Super-Mercuries orbiting the star HD23472. This allowed us to obtain clues about how these planets were formed, which could help us exclude some possibilities. For example, if an impact large enough to create a Super-Mercury is already very unlikely, two giant impacts in the same system seems very improbable. We still don't know how these planets are formed but it appears to be connected to the composition of the parent star.

The star HD23472 was also found to host 3 other planets: this system is composed of three super-Earths with a significant atmosphere and surprisingly two Super-Mercuries, which are the closest planets to the star. Three of the planets have masses lower than that of the Earth.

This result is actually consistent with previous findings, also led by the IA team, suggesting that there is a compositional link between the planet and stellar composition (Adibekyan et al. 2021).

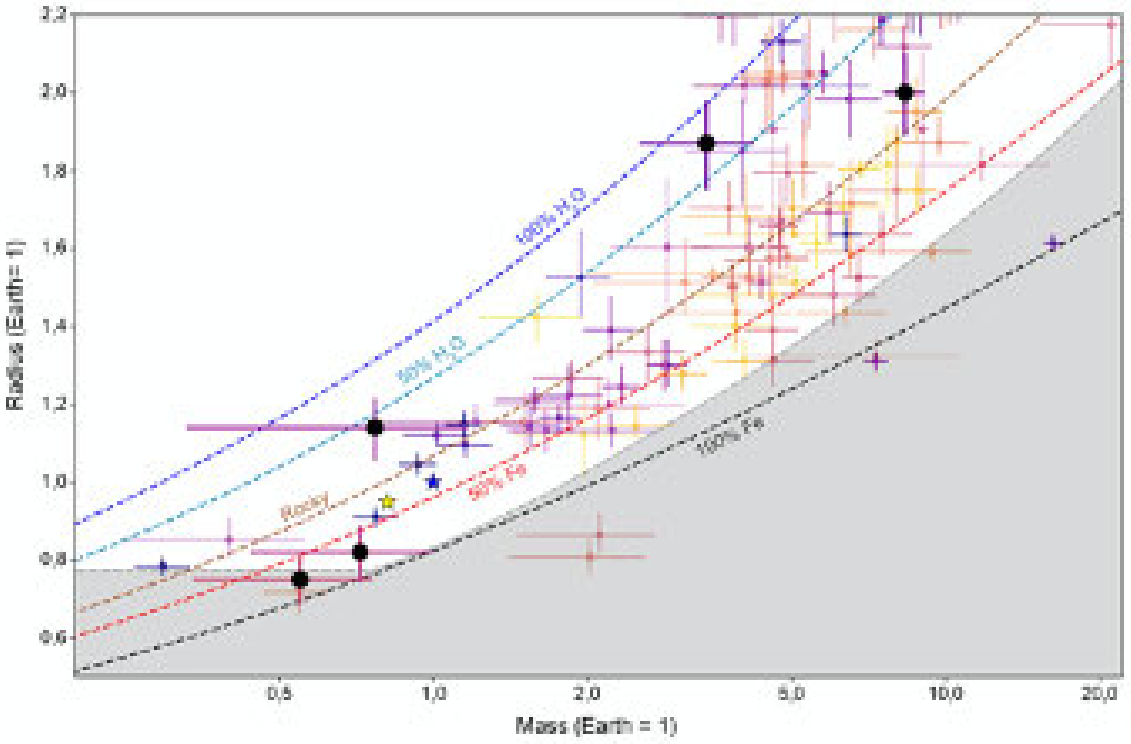


Figure: Position of the 5 planets in the HD23472 system in the mass-radius diagram. Different curves denote the locus of planets with different internal compositions (according to models). The grey area below shows the maximum collision stripping of the mantle region. From Barros et al. 2022 (A&A 665, A154).

A sub-Earth like planet detected around the closest star to the Sun

A team led by IA researcher João Faria found evidence of a new planet orbiting the star Proxima Centauri, the closest star to our Solar System. This candidate planet is the third detected in the system and the lightest yet discovered orbiting this star. It is actually the lightest exoplanet ever measured using the radial velocity technique.

More importantly, this planet has only 0.25 times the mass of the Earth, being the lowest mass planet in the system detected so far. The discovery shows that our closest stellar neighbour seems to be packed with interesting new worlds, within reach of further study and future exploration.

The newly discovered planet, named Proxima d, orbits Proxima Centauri at less than a tenth of Mercury's distance from the Sun. It takes just five days to complete one orbit around Proxima Centauri.

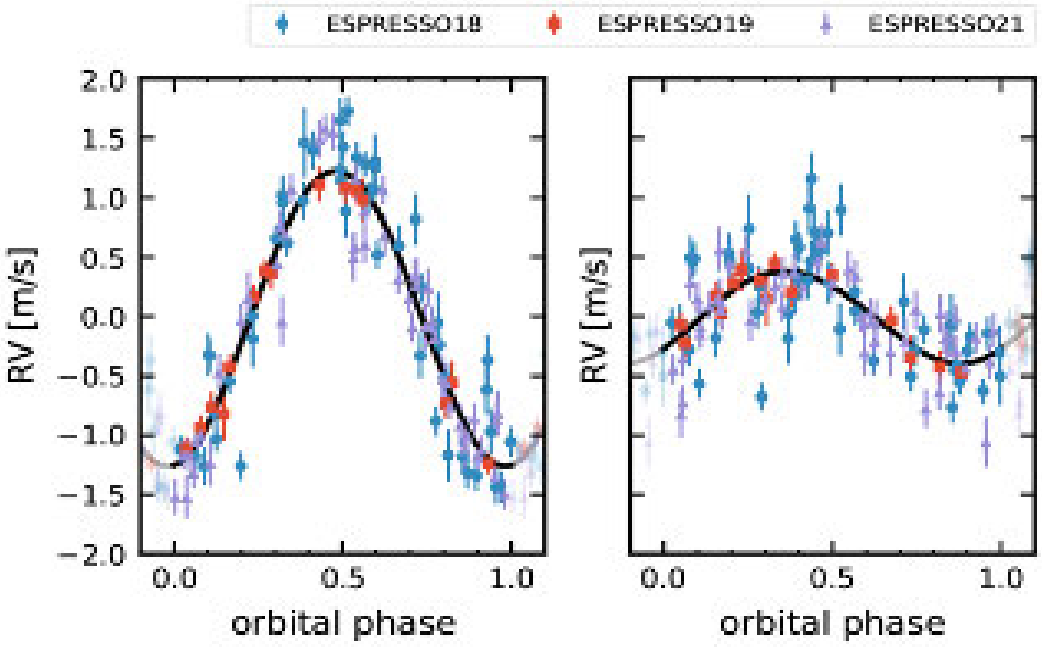


Figure: Radial velocities from ESPRESSO, phase-folded to the orbital periods of Proxima b (left) and Proxima d (right). From Faria et al. 2022 (A&A 658, A115).

The discovery was possible thanks to the ESPRESSO spectrograph (ESO, VLT), and illustrates our strong involvement in this project as well as the relevant scientific leadership results it is bringing to the IA team.

The secret of Venus may be hidden in the heat of the night

The most complete study of the profile of Venus winds parallel to the equator on the nightside launched fresh clues on the possible link between the rampant greenhouse effect of the atmosphere and the violence of the winds at the top of the cloud deck: seventy kilometres above the surface, one has to withstand a perpetual storm-like wind, the product of the so-called Venus superrotation.

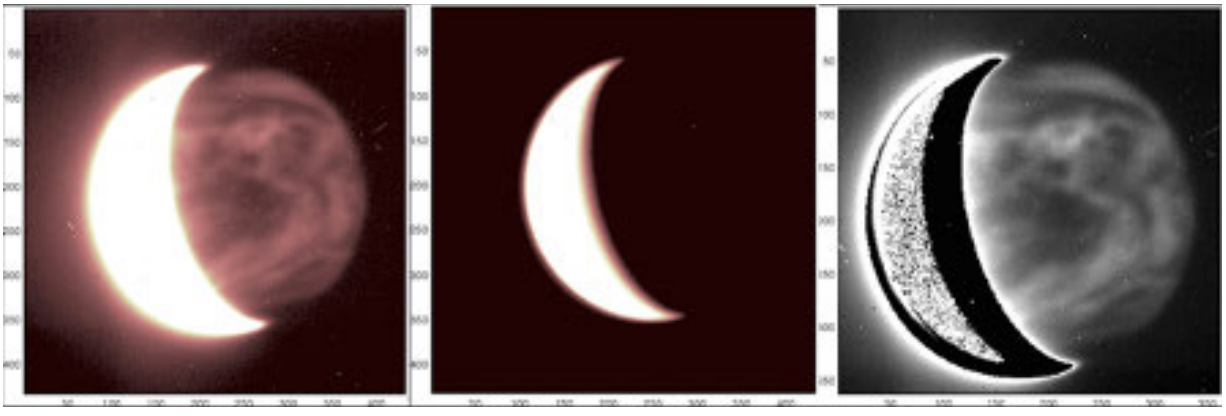


Figure: Venus seen in the near infrared with the Telescopio Nazionale Galileo (TNG). This sequence demonstrates the process of subtracting the brightness of the dayside of Venus, so that the details of the nightside can be analysed. The dark areas on the right side of the first and third image are clouds, while the bright areas are less opaque regions through which escapes the thermal (infrared) radiation from the surface of the planet. From Machado et al. 2022 (Atmosphere 13(2), 337).

One of the novel results was the concurrent measurement of the speed of the wind at different heights. The team registered a difference in wind speed of about 150 kilometres per hour faster at the top of the clouds, which gives clues about how energy is being transferred from the heat of the lower layers to feed the superrotation of the atmosphere.

On the nightside of Venus, the temperature at the ground level reaches 460 degrees Celsius and produces infrared radiation, which heats the air and makes it move up. The team observed Venus in infrared, and saw the light radiated from the heat of the surface, while the silhouettes of the clouds, opaque and dark, become visible. The approach constituted a success for measuring the vertical component of atmosphere's dynamics, that is, how the energy from the lower and hotter layers is carried up to the top of the clouds, where it leads to the acceleration of the winds and to yield the superrotation of the atmosphere.

A rugby-ball shaped planet

Using data from the ESA mission CHEOPS, a team led by IA's researcher Susana Barros measured the shape of the short period giant planet called WASP-103b. Results revealed that it has a deformed shape more like that of a rugby ball than a sphere. This is the first time that the deformation of an exoplanet has been detected, offering new insights into the internal structure of these star-hugging planets.

The planet has been deformed by the strong tidal forces between the planet and its host star WASP-103. For WASP-103b, a planet almost twice the size of Jupiter with 1.5 times its mass and orbiting its host star in less than a day, Astronomers have suspected that such close proximity would cause monumental tides, but up until now they haven't been able to measure them.

The resistance of a material to being deformed depends on its composition. For example, here on Earth we have tides due to the Moon and the Sun but we can only see tides in the oceans. The rocky part doesn't move that much. By measuring how much the planet is deformed we can tell how much of it is rocky, gaseous or water.

This is the first time such analysis has been made, providing a better knowledge of the planet's internal structure and composition.

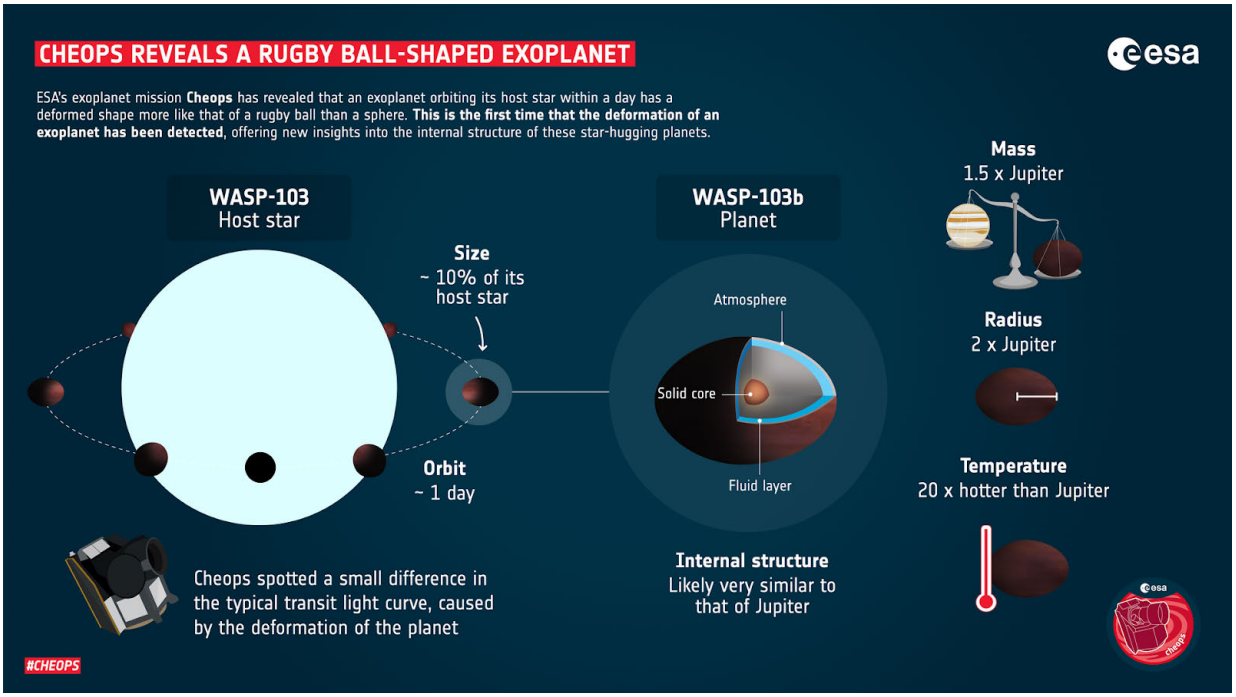


Figure: Schematics of the rugby ball shaped planet WASP-103b. Courtesy ESA and Barros et al. 2022, A&A 657, A52.

Group meetings, Journal Clubs and other activities

In 2022, as for the previous years, the IA-planet group maintained a regular journal club and team meeting agenda. Team meetings and journal clubs are organized every two weeks. Meetings include a presentation of “general information”, as well as a short presentation of the work being carried out by one PhD student, followed by discussion. This format helps the whole team to be acquainted with the research that is being carried out and helps the students to develop presentation skills and identify potential problems and solutions in his/her research project. Journal clubs include the presentation of recent research papers, followed by discussions.

All this information is kept up-to-date in the new team web pages (http://planetas.iastro.pt).

All regular team meetings and journal clubs were performed remotely via Zoom, to assure a smooth participation from team members in all 3 nodes (Porto, Coimbra, and Lisboa).

We also organised our annual team meeting (called "2-DEMOC"), where the team strategy and plans (both scientific and organisational) were discussed. This year's event took place in Aveiro.

A large international conference (Towards Other Earths III) also started its organization in 2022; it will take place in Porto, in July 2023.

Team members actively participated in different public outreach activities, including public talks and debates in schools and online, as well as other outreach events. In this context, the team has also kept updating a public outreach page on Planetary Systems (https://outrosmundos.iastro.pt), where information in Portuguese is provided about planetary system's science as well as the discoveries where the team is involved.

In 2022, 2 PhD thesis and 2 MSc thesis were successfully finished (several others ongoing):

- "Advanced Statistical Data Analysis Methods for the detection of Other Earths", João Camacho (PhD)
- "Characterization of Solar System Planets' Atmosphere Dynamics and small scale waves with Doppler Velocimetry", José E. Silva (PhD)
- “Modelling Venus-like exoplanetary atmospheres with a GCM: planetary parameters impact on the large-scale circulation and observational prospects", Diogo Quirino (MSc)
- "Detection and limits of detection of minor chemical species in Solar System’s atmospheres", João Dias (MSc)

A number of undergraduate students also worked with the IA team in different projects:

- "Exoplanet composition and stellar abundances'', Barbara Silva Oliveira
- "Measuring the size of exoplanets with CHEOPS'', Yuri Carrilho Damasceno
- "Characterization of hot solar-type stars with exoplanets", Cheila Bhuralal and Yuri Damasceno
- "Characterization of hot solar-type stars with exoplanets", Yuri Damasceno
- "Measuring the size of exoplanets with CHEOPS", António Miguel Correia and Bárbara Oliveira
- “The impact of stellar C/O ratios on planet formation“, Bernardo Campilho
- “The enigma of Li-rich giants and its relation with stellar activity”, Inês Rolo Martins

- "Can the Ti I 5713.9 and Fe II 6149.2 A spectral lines be used to follow RV activity noise?", Telmo Monteiro and Carlos António
- "A new activity proxy for finding other Earths", Pedro Afonso
- "Studying the atmospheres of other worlds within and outside the Solar System, Margarida Barros de Oliveira, Moussam Maity
- "Spectral fingerprints of planetary contents", Henrique Eira
- "Exploring Titan's Atmosphere Composition and Temporal Evolution using High-Resolution Spectroscopy and Modelling", Rafael Rianço-Silva
- "Study of Venus atmosphere's polar vortex using cloud tracking techniques and Venus Express (ESA) observations from VIRTIS image spectrometer", André Cipriano
- "Characterising Atmospheric Waves on Mars using Mars Express (ESA) HRSC images", Vasco Silva
- "Identification and interpretation of morphological evidence associated with fluvial-marine environments on Mars", Francisco Rodrigues
- "Interaction Surface/Atmosphere in the framework of EnVision space mission", Constança Freire
- "What are the terrestrial exoplanets made of?", Redyan Ahmed and Naman Joshi
- "Do the chemical mixtures of rocky planets reflect the initial composition of the planet-forming disk?", Matilde Abreu, Mariana Navia and Duarte Branco
- "On the origins of super-Mercuries", Aniket Prasad and Tomás Moura

In 2022, team funding comes mostly from IA "strategic funding" as well as from 4 running FCT projects (3 "normal" ones, that ended mid-2022, and one PEX, still running). Two more PeX projects were funded in the 2022 call, but only start in 2023. To these, we add the ERC Advanced Grant that was mentioned above, that started activities in October 2022.

Furthermore, funding for our participation in the PLATO and ARIEL missions was already secured through PRODEX for the year 2022. We note, however, the PRODEX funding covers only the "project level activities". A continuation of this funding for the period 2023-2025 has been also secured, also adding CHEOPS to the list of space missions presently supported by PRODEX.

We would further like to highlight the strong collaborative work done in 2022 to foster collaborations of IA-Planet team members with other groups in the institute. This particularly concerns collaborations with the Stellar and Instrumentation groups. Collaborations with the stellar group include the characterisation of planet host stars, stellar spectroscopy, and asteroseismology, the study of solar and stellar activity, and Galactic chemical evolution. Instrumentation group collaborations touch several aspects related with the development of new instruments and related software, such as PoET, NIRPS, PLATO, and ANDES. Collaborations with other groups, namely cosmology and science communication, has also been done, respectively, through common instrumentation interests and through the communication of science results.

Nuno Santos
Group Leader

Report from the Group

Towards a comprehensive study of stars

Our activity during 2022 was distributed across three main research lines: **Sun and Heliosphere**, **Stellar Physics**, and **Stellar Populations**.

Sun and Heliosphere research line. We have continued our participation and collaboration in several national and international projects. Group members are leading the Portuguese participation in the SWATNet MSCA Innovative Training Network, are contributing actively to the European Solar Telescope (EST) Preparatory Phase, and are developing the first detailed regional model of the ionosphere. We have also been collaborating in the context of the SUNRISE and Solar Orbiter missions. Our participation in EST is of particular strategic importance. The Portuguese contribution to the project focuses on developing the Integral Field Spectropolarimeter, of which one of the Group members is Co-PI.

Stellar Physics research line. In the context of asteroseismology, we continue to be actively engaged in international consortia related to the NASA space missions Kepler/K2 and TESS. The exploitation of asteroseismic data from TESS is being carried out in the context of the TESS Asteroseismic Science Consortium (TASC), in which our team is strongly involved, with representation on the Steering Committee and co-leadership of one of its working groups. Furthermore, our team continues to be strongly involved in the preparation of the stellar science component of PLATO (ESA), with responsibilities in the design, implementation, and validation of sections of the Stellar Analysis System (SAS) pipeline, leading work packages in the framework of both the PLATO Science Management (PSM) and the PLATO Data Center (PDC). The team has also been contributing to the Ariel (ESA) consortium, in the context of which we coordinate working groups responsible for determining the surface chemical abundances as well as the fundamental properties of the mission's target stars.

The characterization of pre-main-sequence stars and their environments and, in particular, T Tauri stars (TTSs), is being achieved using several strategies, namely, photometric analysis of circumstellar disks around Classical T Tauri stars (cTTSs), spectroscopic studies (UV and visible) of signatures of outflows and accretion rates, and spectropolarimetric observations using SPIRou@CFHT of the complex magnetic field structures permeating TTSs. The team's involvement in SPIRou is of particular significance, with one of its members being part of the consortium's Steering Committee.

Stellar Populations research line. We continue to be actively engaged in several international consortia, including ANDES@ELT, the Maunakea Spectroscopic Explorer (MSE), ESPRESSO@VLT, NIRPS@ESO 3.6-m Telescope, and the Gaia-ESO Survey (concluded), among others. Of particular note, the ANDES project has started pre-Phase B in September 2022. Our team has a strong involvement in this project, playing a role in the development of its scientific priorities and the definition of top level requirements for the instrumentation. Furthermore, HAYDN has been selected by ESA in November 2022 for a Phase-0 study (on which more below).

Scientific highlights for 2022

Forecasting space weather

In Morozova, Barata & Barlyaeva (2022, Atmosphere, 13, 323), the authors propose a forecasting model to help avoid potentially hazardous space weather effects on Global Navigation Satellite System-based services, such as air navigation. Ionospheric and space weather parameters were analysed for quiet and disturbed days using principal component analysis and multilinear regression in order to forecast the ionosphere for middle latitudes, which includes Portugal (see Fig. 1). Note that, to date, no ionosphere model exists for mainland Portugal and its archipelagos. The PRIME FCT R&D project (PI: Morozova) aims at developing such a prototype model, which will likely play an important role not only in integrating the ESA Space Weather Service Network, but also in supporting the air navigation sector (Portugal is located on the border of the EGNOS system, a satellite-based augmentation system for Galileo).

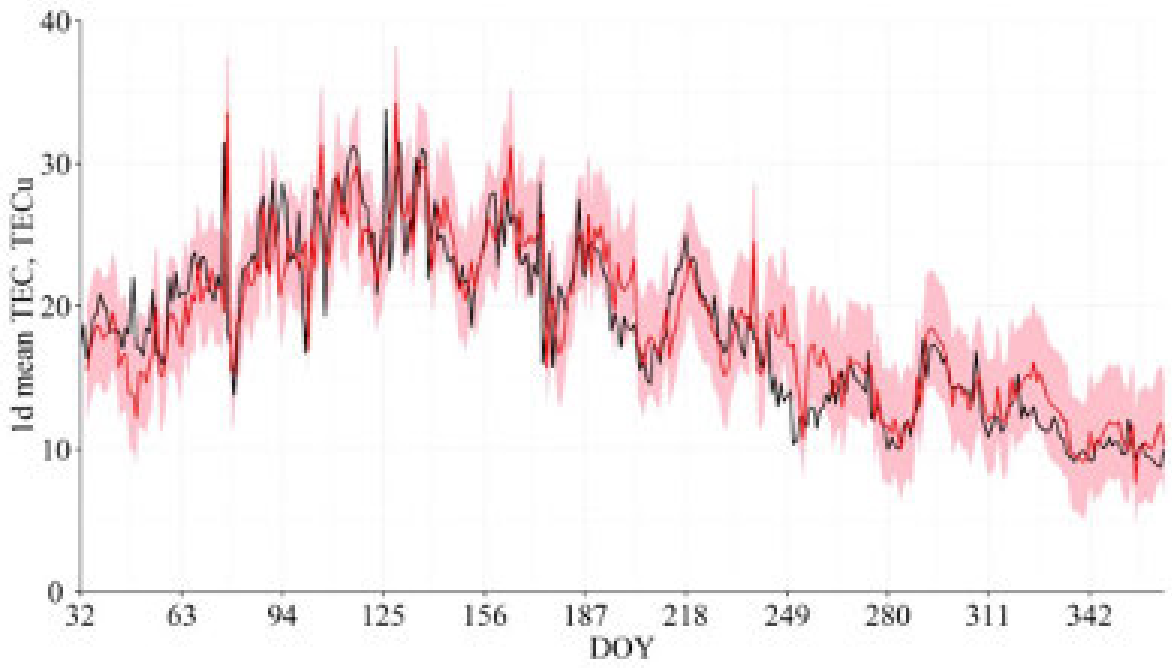


Figure 1: Observed (black) and forecasted (red) daily mean TEC (total electron content) time series for February–December 2015. The shaded pink area shows the 90% confidence interval. From Morozova, Barata & Barlyaeva (2022).

Probing the cores of red-giant stars

In Vrard et al. (2022, Nature Communications, 13, 7553), the authors used asteroseismic data from the NASA Kepler mission to diagnose structural discontinuities in the cores of red-giant clump stars. They found evidence for large core structural discontinuities in about 6.7% of the stars in the sample (sample size: 359 stars; see Fig. 2), implying that the region of mixing beyond the convective core boundary has a radiative thermal stratification. These stars are otherwise similar to the remaining stars in the sample, which may indicate that the building of the discontinuities is an intermittent phenomenon. This work sets important constraints on state-of-the-art models for this particular type of star, reinforcing their use as Galactic

probes, and is an output of the BreakStarS FCT R&D project (PI: Cunha), completed in April 2022. A press release was issued by IA announcing this result.

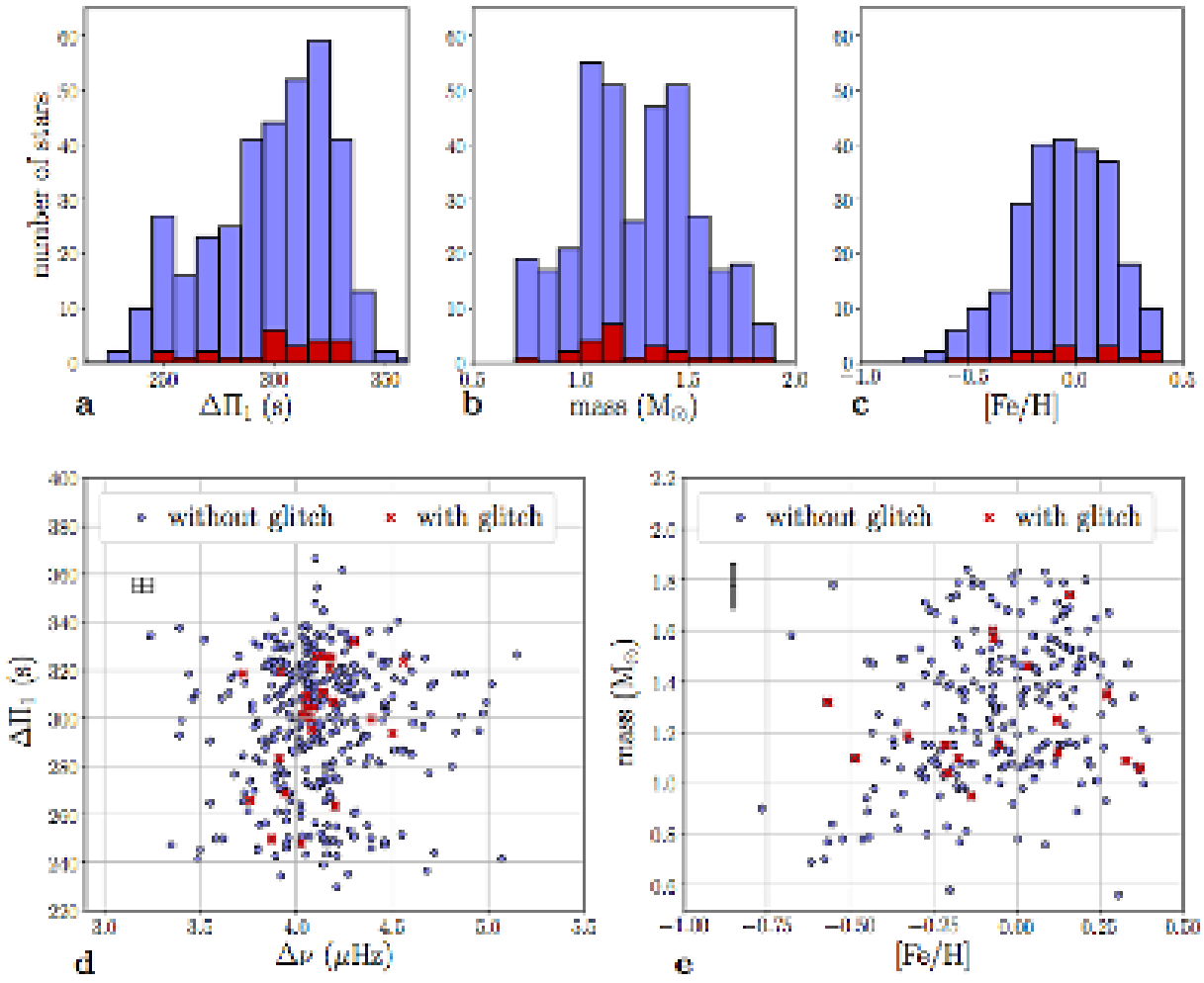


Figure 2: Histograms representing the number of stars as a function of the period spacing (panel a), mass (panel b), and metallicity (panel c) present in the full sample (in blue) and for which a discontinuity was found (in red). Period spacing as a function of the large frequency separation (panel d) and stellar mass as a function of metallicity (panel e) for the total analyzed sample (blue circles) and the stars for which a discontinuity was found (red crosses). From Vrard et al. (2022).

Atomic diffusion and turbulent mixing in solar-like stars

In Moedas et al. (2022, Astronomy & Astrophysics, 666, A43), the authors implemented turbulent mixing in stellar models and assessed the possibility of reproducing the effect of radiative accelerations (with turbulent mixing) for elements like iron in order to make the calculation of large grids of stellar models less computationally demanding. They found that, for iron, a parameterization of turbulent mixing that simulates the effect of radiative accelerations is possible. This leads to an increase in the efficiency of the turbulent mixing to counteract the effect of gravitational settling. Moreover, this approximation does not significantly affect the surface abundances of other elements investigated by the authors, with the exception of oxygen and calcium (see Fig. 3).

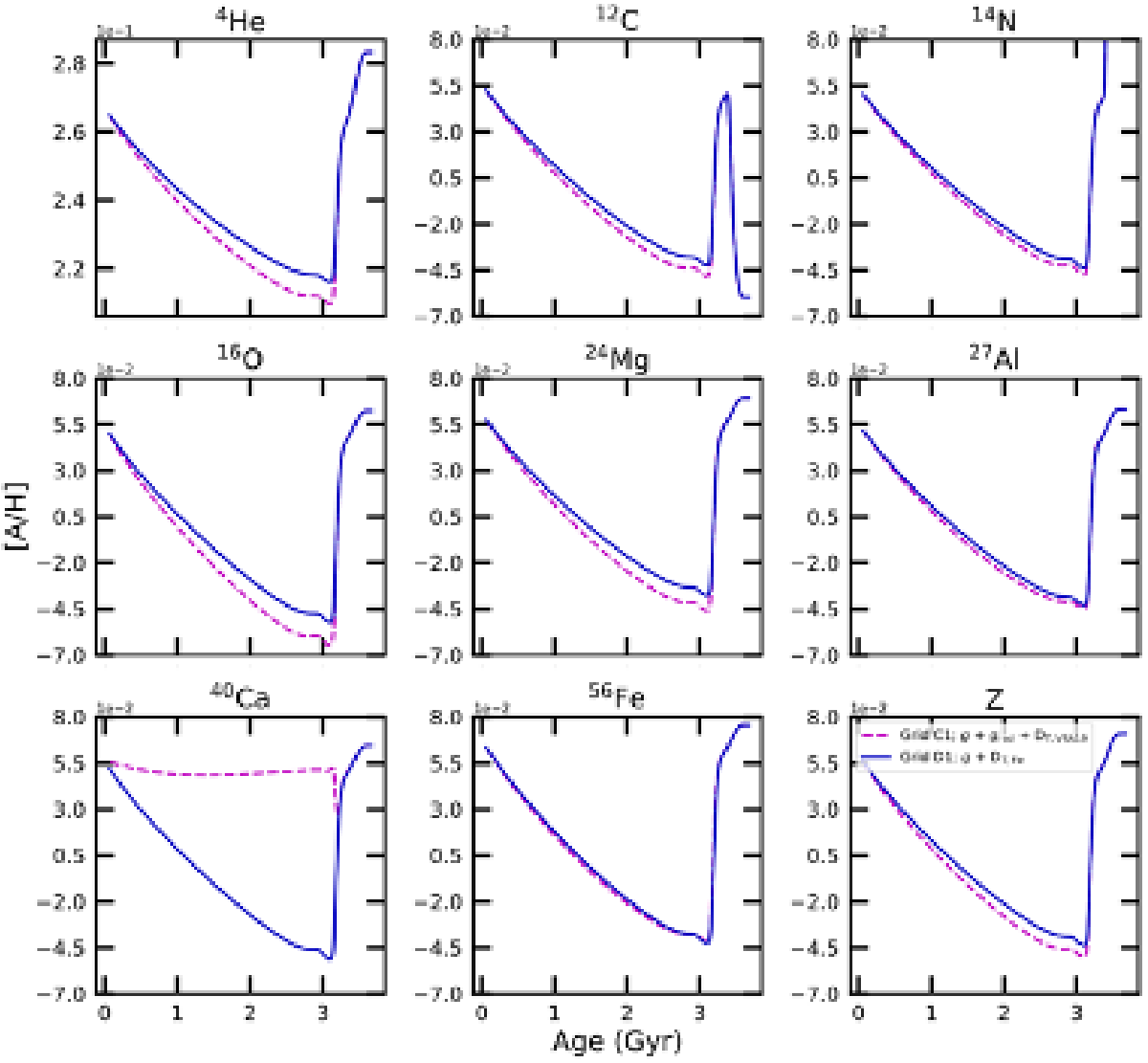


Figure 3: Evolution of the surface abundances of several chemical elements for a 1.4 solar-mass model. Purple dashed lines represent a model including atomic diffusion with radiative accelerations and the turbulent mixing calibrated by Verma & Silva Aguirre (2019, MNRAS, 489, 1850), whereas blue solid lines represent a model including atomic diffusion without radiative accelerations and the parameterization of turbulent mixing derived by the authors. From Moedas et al. (2022).

COSPAR ISWAT2022

The 3rd Working Meeting of the COSPAR International Space Weather Action Teams (ISWAT) was held between the 26th and the 30th of September 2022 at the University of Coimbra. The meeting was organized locally by Group members and welcomed nearly 70 participants. The ISWAT initiative is a global hub addressing challenges in the field of space weather. This meeting brought together the ISWAT community in order to finalize the preparation of the community-driven Space Weather Roadmap, to review the status of ongoing ISWAT projects, and to plan new actions and collaborations based on the Roadmap guidelines.

Figure 4: Poster of COSPAR ISWAT2022.

HAYDN selected for a Phase-0 study

HAYDN (High-precision AsteroseismologY of DeNse stellar fields), which had been proposed as a mission concept in response to ESA's call for an M-class mission (Voyage 2050 long-term plan), was selected for a Phase-0 study in November 2022. Group members are involved in both the science and payload consortia. HAYDN is meant to collect high-cadence, long photometric time series of dense stellar fields. If selected, it will lead to breakthroughs in stellar astrophysics, especially in the metal-poor regime, shed light on the evolution of open and globular clusters, and help us understand the assembly history and chemodynamics of the Milky Way bulge and of a few nearby dwarf galaxies.

Other activities

We start by providing an overview of the Group's internal procedures and meetings. Next, we highlight a number of indicators for the year 2022, namely, funded projects, completed theses, organization of conferences and workshops, and outreach.

Regular meetings and activities

We hold biweekly Group meetings, a forum for discussing Group-related issues and strategy. These are held together with the Journal Club. Moreover, we hold science meetings on a biweekly basis (alternating them with the Group meetings), a forum for presenting and discussing ongoing work conducted by Group members. In 2022, we had two more installments of Stars Day (one in May and the other one in December), a biannual in-person meeting with a strong social component. Stars Day events are fully organized by our students. Finally, we also held the annual 'SOAR analysis' meeting.

Communication

The Group website is regularly updated, containing news as well as information on our research and other activities. This past year, we have also created a Slack workspace for file sharing and everyday communication among Group members.

Funded projects (starting, finishing, or ongoing in 2022)

FCT R&D projects:

- 1 regular project.
- 1 exploratory project.
- 3 exploratory projects awarded (all starting in 2023).

Estímulo ao Emprego Científico Individual:

- 2 Principal Investigator contracts.
- 2 Assistant Researcher contracts.
- 1 Junior Researcher contract.
- 1 Principal Investigator contract awarded (starting in 2023).
- European funding:
- Revealing the Milky Way with Gaia (MW-GAIA) — COST Action.
- Space Weather Awareness Training Network (SWATNet) — MSCA Innovative Training Network.
- SSA P3-SWE-XXXVII SWE Products for Southern Europe — Phase 1 (PROSE).

Completed theses

MSc:

- Andreas Neitzel. Title: *Determination of age and mass for seismic stars in the Ariel input catalog.* Supervisors: Diego Bossini and Tiago Campante.
- Margarida Santiago. Title: *Evolution and dynamics of solar H-alpha filaments and their relation with Space Weather events*. Supervisors: Ricardo Gafeira.
- Pedro Martins. Title: *O ambiente de novos enxames estelares jovens na Galáxia exterior: um estudo no milímetro e no infravermelho*. Supervisors: João Yun.

Organization of conferences/meetings/workshops

- Solar and Stellar Coronal Mass Ejections — Splinter Session at Cool Stars 21.
- COSPAR International Space Weather Action Teams (ISWAT) 3rd Working Meeting.

Outreach

- 5 Group-related press releases/news articles published by the Science Communication Group.
- Partnership with National Geographic Portugal: 1 article by Group members.
- IAstro Summer Internship program: 1 project led by Group members.
- 3 courses in Astronomy and Astrophysics currently being offered by Group members.

Tiago Campante
Group Leader

Report from the Group

The assembly history of galaxies resolved in space and time

In 2022, the Group continued to implement its strategic plan, gradually returning to face-to-face communications thanks to the decline of the COVID19 pandemic, and by intensifying its efforts toward the exploration of the formation history of galaxies and their structural components, of the genesis and growth of super-massive black holes (SMBHs) in galactic nuclei and their influence on the assembly history of galaxies, the mechanisms triggering and regulating starburst activity and its role on the galaxy stellar mass growth, and the influence of the environment on galaxy evolution.

These science goals which are being pursued by a team of 13 researchers, 12 collaborators and 12 students, are served by the participation of IA with leadership roles in the instrument consortia of MOONS@VLT, BlueMUSE@VLT, MOSAIC@ELT of ESO, and ESA missions with key relevance to the strategy of the Group (Euclid, Athena), as well as by the parallel development of highly optimized computational tools for the scientific exploitation of multi-wavelength data for galaxies near and far.

The growth of SMBHs and their observational manifestations as Active Galactic Nuclei (AGN) is being investigated by the Group both at highest redshifts and in the nearby universe. The emergence of the very first powerful AGN in the Universe, and how they shaped the earliest galaxy evolution is being studied through sub-mm observations with IRAM and the revolutionary ALMA, and by post-processing cosmological simulations to obtain quantitative predictions on the number and detectability of early SMBHs at X-rays and radio wavelengths. Building upon its expertise on the analysis and interpretation of multi-wavelength data, and as part of a coherent strategic roadmap, the Group is developing new observational discriminators for the detection of proto-AGN at the Epoch of Reionization (EoR). It also acts as a strong driver in the development of the future ASKAP's Evolutionary Map of the Universe survey, through the IA-lead Key Science Project "Radio AGN in the EoR" and is represented at the Board and Science team level in ESA's future X-ray mission, Athena.

At low and intermediate redshift (z), the AGN phenomenon is being studied using the currently most powerful telescopes and instruments, most notably the Multi Unit Spectroscopic Explorer (MUSE) at ESO-VLT. Special emphasis is being laid on the study of quasars surrounded by gigantic Lyman-α halos and the definition of new diagnostics for constraining the physical conditions and excitation mechanisms in the nebular component of these extreme environments. This line of research is further supported by a comparative analysis of gas kinematics and excitation properties obtained from integral field spectroscopy (IFS) with predictions from cosmological simulations incorporating AGN feedback, and through IA's spectral synthesis code FADO. The latter, together with other IA-developed tools, are being used to prepare the scientific exploitation of MOONS (the Multi Object Optical and Near-infrared Spectrograph for the VLT), an instrument the IA co-leads and which is expected to start its operation in 2024.
During 2022, the team continued having a key involvement in the preparation of guaranteed time observations with MOONS and in the definition of strategies for the reduction and analysis of data from it. IA researchers assume major roles in several MOONS Science and Technical Working Groups (WGs), including the co-leadership of the AGN WG and the technical WG-1, and have an active role in the scientific WGs on Physics of the ISM, Passive galaxies and stellar continuum, Galaxy environment, Large-Scale

Structures, High-z Universe and the EoR, Clusters/Protoclusters, and in the technical WGs on Mock Catalogues from Simulations, Determination of Redshift and Physical Parameters from Spectra, and on the Determination of Environmental Parameters.

Another important field of the activities of the Group centers on spatially resolved investigations of galaxies with IFS and deep multi-band photometry. Using MUSE and the CALIFA and MaNGA IFS galaxy surveys, team members are investigating a wide range of fundamental issues in extragalactic research, including the build-up history of galaxy bulges and the physical drivers of their inside-out star formation quenching, age and metallicity patterns in spiral and elliptical galaxies, cooling flows and ram pressure stripping effects in galaxy clusters, gas kinematics and excitation mechanisms in elliptical galaxies, the evolution of the ionizing photon efficiency across cosmic time, massive Wolf-Rayet stars and the diffuse ionized gas in star-forming galaxies, and the nature of ultra-faint galaxies. Furthermore, using ALMA, MUSE and FADO the team is studying the action of starbursts on the molecular gas phase in extremely metal-poor dwarf galaxies, which may be considered the best local analogs of the first proto-galactic units that emerged at the EoR. The activities of the team also encompass the development of Machine Learning tools for the identification of high-z AGN and the characterization of galaxies from the Euclid Galaxy Legacy Survey, which is co-led by IA.

Scientific Highlights for 2022

AGN and the growth of SMBHs since the Epoch of the Reionization

Farrah ... Afonso et al. 2022a (ApJ, submitted) have investigated the assembly of stellar and SMBH mass (M_* and $M_\bullet$, respectively) in elliptical galaxies (ETGs) using galaxy samples spanning a redshift (z) between 0 and 2.5, and by quantifying the relative position of these galaxies in the $M_\bullet$ vs. M_* plane. They found evidence for translational offsets in both M_* and $M_\bullet$ between the local sample and higher-z samples. Whereas the offsets in stellar mass are small, and consistent with measurement bias, the offsets in $M_\bullet$ are much larger, reaching a factor of 7 between $z\sim1$ and $z\sim0$. A Bayesian analysis carried out by the authors suggests that either there is a physical mechanism that preferentially grows SMBHs in ETGs at $z < 2$, or that selection and measurement biases are both underestimated, and depend on redshift.

In a follow-up study Farrah ... Afonso et al. 2022b (ApJ, submitted) used the previously analysed sample of ETGs to test the prediction from black hole models with realistic behaviour at infinity that the gravitating mass of a black hole can increase with the expansion of the Universe independently of accretion or mergers, in a manner that depends on the black hole's interior solution. This study finds evidence for cosmologically coupled mass growth among these black holes, with zero cosmological coupling excluded at 99.98% confidence. The redshift dependence of the mass growth implies that, at $z < 7$, black holes contribute an effectively constant cosmological energy density to Friedmann's equations. The continuity equation then requires that black holes contribute cosmologically as vacuum energy. An important proposal that has emerged from this study is that stellar remnant black holes are the astrophysical origin of dark energy, explaining the onset of accelerating expansion at $z \sim 0.7$.

Farrah, Efstathiou, Afonso et al. 2022c (Universe, submitted) examine the origin of molecular gas heating in a sample of 42 infrared-luminous galaxies at $z < 0.3$. They find that the CO 1–0 and 5–4 through 9–8 lines primarily arise via radiative heating in the starburst and the host galaxy. In contrast, the CO 10–9 through 13–12 CO lines may arise primarily in the starburst and AGN, with an increasing contribution from mechanical heating and shocks.

Studies of high-redshift galaxies with the James Webb Space Telescope (JWST)

The advent of JWST has stimulated a number of parallel research projects by our team and collaborators. In particular, Brinchmann (2022, A&A, submitted) has carried out a critical examination of 14 galaxies with available JWST NIRSpec data at a redshift $1.2 < z < 8.5$. He devised a modification of the direct abundance determination method that reduces the dependence of metallicity determinations on the flux calibration uncertainties by a factor ~3. Two of the most important results from this study were that shocks provide a substantial contribution to the gas excitation in galaxies at $z \lesssim 3$. This IA researcher has additionally demonstrated that studies of the mass-metallicity relation at those redshifts using galaxy samples with detected auroral [OIII]4363 line emission can introduce serious biases, given that such galaxies form a special subclass of low-metallicity, high-excitation sources. This study has shown instead that Bayesian photoionization modeling of strong lines is preferable to using temperature-sensitive emission lines.

Parallel efforts by the team in the context of JWST focus on spectral modeling of star-forming galaxies with the goal of exploring their early star formation history (SFH), as well as simulations of the morphology and color patterns of high-redshift galaxies in the JWST filters (Sect. 7).

Physical characterization of galaxies with Machine Learning (ML) tools

a) Investigations of SMBH growth and the associated AGN activity across cosmic time have been supported by the development and application by our IA team of ML tools aiming to devise new indicators for radio-powerful AGN at high redshift. Recent studies have shown that, for epochs earlier than $z \sim 5$, the number density of SMBHs is on the order of a few hundreds per square degree. Latest observations place this value below 300 SMBHs at $z \gtrsim 6$ for the full sky. To overcome this gap, it is necessary to detect large numbers of sources at the earliest epochs. Given the large areas needed to detect such quantities, using traditional redshift determination techniques (spectroscopic and photometric redshift) is no longer an efficient task. ML techniques are advantageous in this regard, as they permit obtaining precise redshifts for large samples in a fraction of the time used by other methods.

Following an initial realization of the concept published in Carvajal, Matute, Afonso et al. 2021, (MDPI Galaxies, vol. 9, 86) that allowed ML-supported predictions of redshifts for WISE-detected AGN, the IA team has further refined and improved various criteria for an automated separation of AGN from normal (star-forming or quiescent) galaxies at high-z (Carvajal, Matute, Afonso et al. 2022, MNRAS, submitted). This improved algorithm is going to be applied to the Evolutionary Map of the Universe Survey (EMU) Pilot Observations, now available.

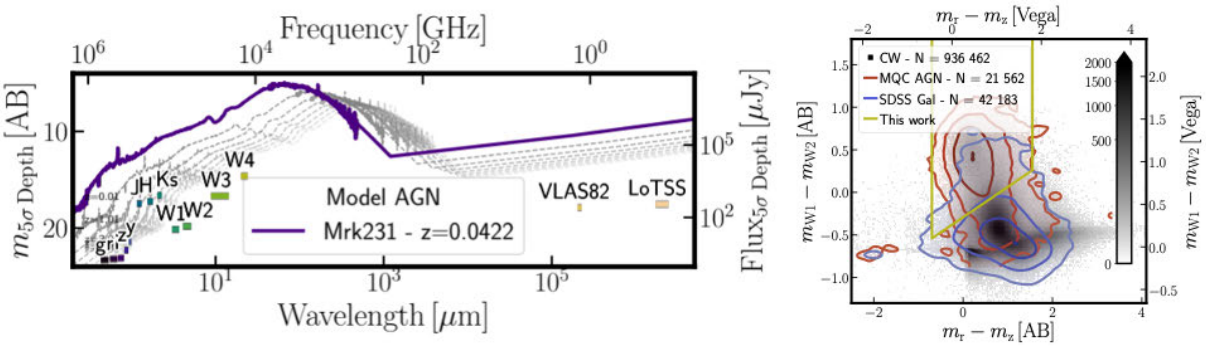


Fig. 1, left: Modeling of the spectral energy distribution (SED) of the AGN-hosting ultraluminous IR galaxy Mrk231 at different z (left). right: Separation of AGN from normal galaxies on a two-color diagram constructed using ML tools (from Carvajal et al. 2022).

b) Another line of ML-supported research by the IA-Galaxies team centers on Lyman-α-emitting (LAE) galaxies. Paulino-Afonso has initiated the FLAEMING project, which is a new effort that leverages data-rich surveys such as COSMOS to train ML models for identifying LAE candidates. She has successfully trained a model that can classify LAEs with approximately 90% accuracy using only optical and near-infrared fluxes. An application of this model to the COSMOS field has permitted the prediction of the existence of ~3500 new LAE candidates not detected by the SC4K survey, effectively doubling the existing sample. Two parallel projects in this context use a) gradient-boosting algorithms trained from COSMOS2015 and SC4K to improve LAE identifications, and b) Convolutional Neural Networks for the search of LAEs from broadband data. These three aforementioned projects strongly benefit from GPUs awarded to Dr. Ana Paulino-Afonso in the framework of the NVIDIA Academic Hardware Grant Program.

c) Another set of projects carried out by the IA Galaxies Group centers on the scientific exploitation of data with the upcoming Euclid space observatory. Following the development and validation of a ML technique for the classification of astronomical sources (Humphrey et al. 2022a, MNRAS, 517, L1), and their photometric redshift-aided classification using ensemble learning with particular focus on the efficient discrimination between high-z quasars and foreground Galactic stars (Cunha & Humphrey 2022, A&A 666, 87), our team has extended ML techniques toward estimating galaxy redshifts and physical properties of galaxies using unlabelled observations (Humphrey et al. 2022b, A&A, submitted) and the selection of quiescent galaxies from mock photometry in the Euclid Galaxy Legacy Survey (Humphrey et al. 2022c, A&A, submitted).

The influence of the environment on galaxy evolution

The team has continued its studies of the action of the environment on galaxy evolution, both in galaxy clusters and compact galaxy groups.

New insights into this fundamental subject could be gained through interferometric studies of the hydrogen 21 cm line of selected galaxies in the cluster Abell 1367. In this regard, extending a previous study of selected sources, in particular on the enigmatic galaxy triplet FGC 1287 in the outskirts of the galaxy (Scott … Lagos et al. 2022, MNRAS, 511, 9), T. Scott has participated in a study of the field around that cluster with the Arecibo Galaxy Environment Survey (Deshev … Scott et al. 2022, A&A 665, 155).

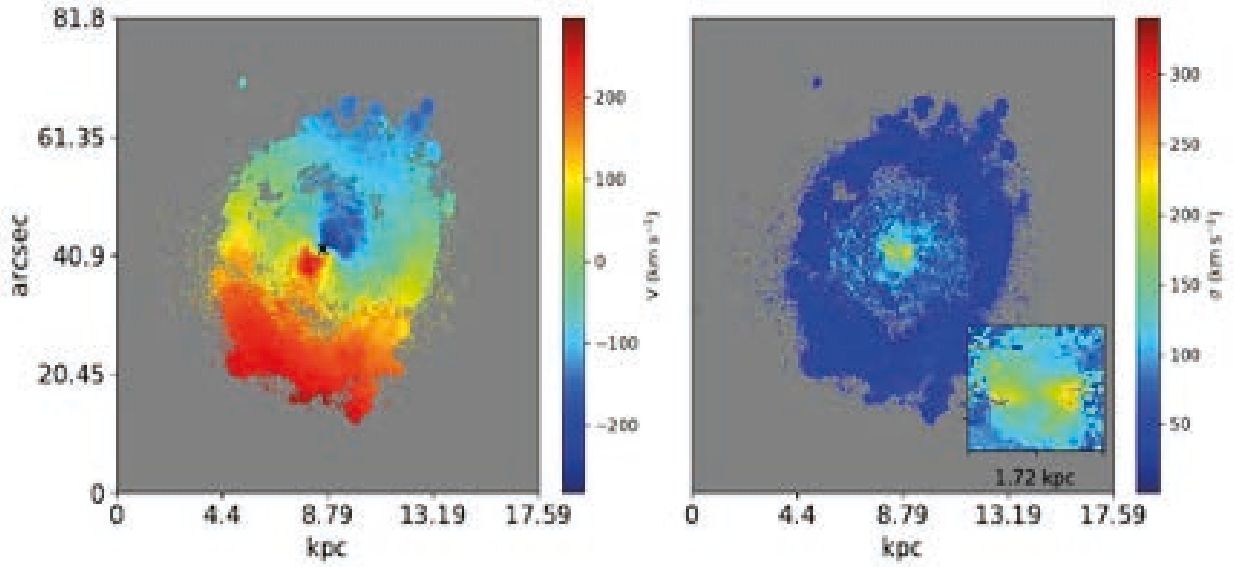


Fig. 2: Example of the analysis of group-dominant galaxies by Lagos … Scott et al. (2022). Gas velocity (left panel) and gas velocity dispersion (right panel) obtained for the galaxy ESO0507-G025 from fitting the [NII]6583 emission line. The position of the continuum maximum is indicated by the X symbol.

Another study centers on gas excitation mechanisms in massive (>1012 M⊙) galaxies in the densest known galaxy clusters. Lagos … Scott et al. (2022, MNRAS, 516, 54) by applying the IA-developed spectral synthesis code FADO (Gomes & Papaderos 2017) to deep MUSE IFS data for 18 group-dominant galaxies (all of those classified as Ellipticals and S0) were able to accurately subtract the underlying stellar continuum and perform a thorough analysis of gas-phase metallicity patterns and excitation diagnostics. An insight gained from this study is that the nuclei of group-dominant galaxies typically show LINER-like emission-line ratios that hint at an AGN, and that extranuclear star-forming regions in some S0s are chemically homogeneous. Various lines of evidence presented by these authors suggest that group-dominant galaxies likely acquired their cold gas through accretion and/or cooling flows.
This large-scale program is supplemented by studies focusing on further physical and evolutionary characteristics of the galaxy sample, such as the morphology and kinematics of gas in BCG (Olivares … Scott et al. 2022, A&A 666, 94), the star formation and gas content of BCGs (Kolokythas .. Lagos 2022, MNRAS 510, 41), and the merger histories of these systems as revealed from stellar kinematics (Loubser, Lagos et al. 2022, MNRAS 515, 11).

Extremely metal-poor starburst galaxies and other extreme emission-line galaxies

A significant effort by the team has been dedicated to investigations of extremely metal-deficient (12+log(O/H)<7.6) blue compact dwarf (BCD) galaxies and green peas (GPs), as the best local proxies of actively star-forming galaxies in the early Universe.

New, very deep VLT-MUSE data have allowed the detection of a spectacular 15 kpc outflow in the BCD SBS 0335-052E. A combined interpretation of optical IFS data with HI interferometry acquired with the VLA in its B-configuration suggests that Lyman continuum (LyC) radiation produced by young massive stellar clusters in this BCD is escaping anisotropically, in the direction of the outflow (Herenz .. Papaderos et al. 2022, A&A 670, 121). The observational evidence for anisotropic LyC photon leakage may have major implications to our understanding of the role of low-mass galaxies for the reionization of the Universe.

Brinchmann has a key involvement in studies of the UV properties of low-mass starburst galaxies from the COS Legacy Archive Spectroscopic Survey (CLASSY), from the definition of the survey (Berg .., Brinchmann et al. 2022, ApJS, 261, 31) and its technical overview (James … Brinchmann et al. 2022, ApJS 262, 37), to detailed studies of UV diagnostics of the physical conditions of the interstellar medium (Mingozzi … Brinchmann et al. 2022, ApJ, 939, 110), and estimations of the impact of aperture effects on the inferred nebular properties of these local analogs of high-z protogalaxies (Arrelano-Córdova .. Brinchmann et al. 2022, ApJ, 935, 74).

The extremely metal-deficient BCD CGCG007-025 has been the subject of two dedicated articles with the key participation of our IA team. The first one (Fernández .. Papaderos et al. 2022a) uses deep optical spectra with 10.4m GTC, in conjunction with spectral modeling with FADO, and a 16-dimensional model, which for the first time, simultaneously explores the direct method and the photoionization parameter space. Both techniques consistently indicate a low-metallicity interstellar medium (7.76 < 12+log(O/H) < 8.04) ionized by strong radiation from young SSCs.

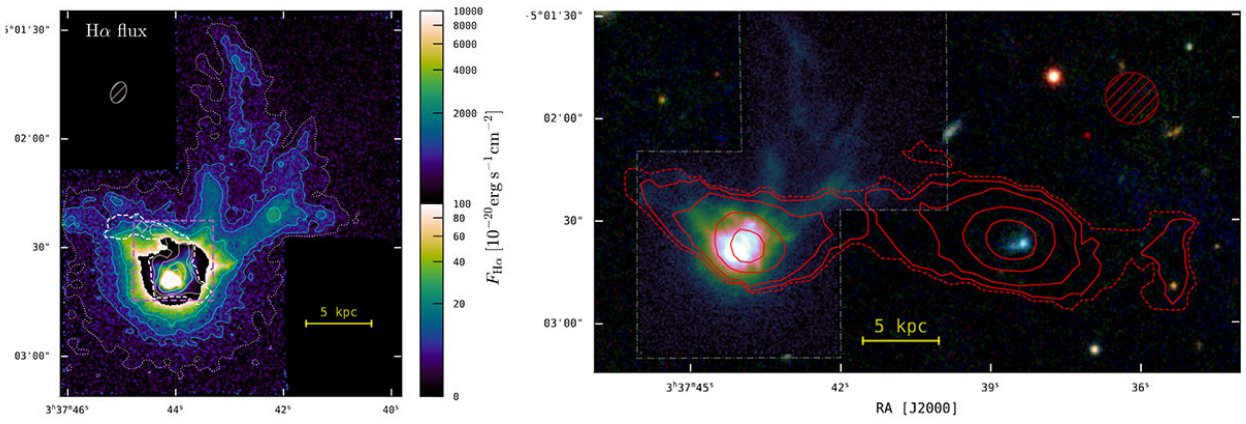


Fig. 3 **left**: Continuum-subtracted Hα narrowband image of SBS 0335-052E revealing the spectacular starburst-driven outflow of this BCD. **right**: HI VLA map of SBS 0335-052E and its faint western companion (from Herenz … Papaderos et al. 2022).

The aforementioned direct method versus photoionization model fitting concept was further applied in Fernández … Papaderos (2022b, MNRAS, submitted). Further insights into the spatially-resolved chemodynamics of CGCG 007-025 have emerged through a subsequent study by de Valle-Espinosa .. Papaderos (2022, A&A, submitted).

In a related context, our team has investigated with FADO the stellar content of extreme emission-line galaxies (EELGs) from the Sloan Digital Sky Survey (SDSS) (Breda, Vílchez, Papaderos et al. 2022) and the SFH and emission-line diagnostics in the starburst region Mrk59 of the cometary BCD NGC4861 (Roche … Papaderos et al. 2022, MNRAS, submitted).

Finally, Papaderos in collaboration with researchers from Stockholm University (Östlin, Hayes, Bik) has initiated a combined investigation of the connection between the SFH and the properties of extended Lyman-α and Hα halos in BCDs, including the prototypical systems Haro11 and ESO338-IG04.

Fundamental scaling relations and the physical drivers of star formation quenching in galaxies

In preparation of the exploration with VLT MOONS (to start its operations in 2024) of the evolutionary history and chemical properties of galaxies and AGN at the critically important cosmic epoch around z~1, the IA team has intensively applied the spectral synthesis code FADO for studies of the slope and scatter of fundamental galaxy scaling relations in the low-z universe.
Special emphasis in this regard was placed on the influence of nebular continuum on the physical properties of galaxies, as retrieved from spectral modeling of their spectra.
From a comparative analysis of the spectral synthesis output from FADO with that from the code Starlight for nearly one million spectra from the SDSS, Cardoso et al. (2022, A&A 667, 11) concluded that the neglect of nebular continuum emission in conventional (purely stellar spectral modeling codes) substantially impacts the inferred evolutionary properties of galaxies (e.g., mean age and metallicity). In turn, this can significantly bias determinations of fundamental galaxy scaling relations, such as mass-age or mass-metallicity, especially for actively star-forming galaxies at z>1. Additionally, the influence of nebular emission on the slope and scatter of the star-forming main sequence was studied in detail in Miranda et al. 2022 (A&A, submitted), with a parallel investigation by Duarte Santos et al. (2022, in prep.) focusing on the effect of nebular emission on galaxy stellar mass determinations and the connection between M✶ and gas excitation mechanisms. In a related context, FADO was applied to type Ia supernova host galaxies at intermediate-and high redshift with the goal of inferring their star formation- and metallicity enrichment histories (Millán-Irigoyen … Gomes et al. 2022).

The physical drivers and corresponding timescales of star formation quenching (SFQ) in galaxies constitute a key topic to be investigated by our team with the upcoming VLT-MOONS. For this reason, Breda & Papaderos (2022, A&A, submitted) have used IFS data for 135 galaxies from the CALIFA survey to investigate the connection between present-day galaxy mass and the timescale of SFQ. Through a combined population and evolutionary spectral synthesis approach, these researchers have devised a semi-empirical parameterization for the decline of the star formation rate both in the bulge and the disk component as a function of present-day M✶.

Finally, Papaderos, Breda, Gomes, Humphrey & Pappalardo (2022, A&A 658, 74) have explored from the photometric point of view how the usual neglect of inside-out SFQ influences bulge-disk decomposition studies of galaxies. The main result from this study was that subtraction of an exponential model to the star-forming disk from a galaxy image leads to the over subtraction of the disk from the old, passively evolving bulge, consequently to a systematic underestimation of the luminosity (and M✶) of the latter. This effect can, in turn, can substantially bias the slope, and its possible change across z, of the SMBH vs. M✶ relation, it thus needs to be accounted for in image decomposition studies both of local and higher-z galaxies.

Morphological and structural properties of galaxies at higher-redshift with the JWST and Euclid: the chromatic surface brightness modulation (CMOD) effect

Motivated by the fact that the investigation of the structural and morphological evolution of galaxies with the JWST and Euclid is one of the central scientific goals of IA's Galaxies Group for the coming years, IA researchers have examined in Papaderos, Östlin & Breda (2022, A&A, submitted) how the usual neglect of a

k correction (or the application of one single k correction to a galaxy as a whole, both to its non-star-forming bulge and star forming disk) could impact bulge-disk decomposition studies of higher-z galaxies, consequently also the SMBH vs. M✶ relation.

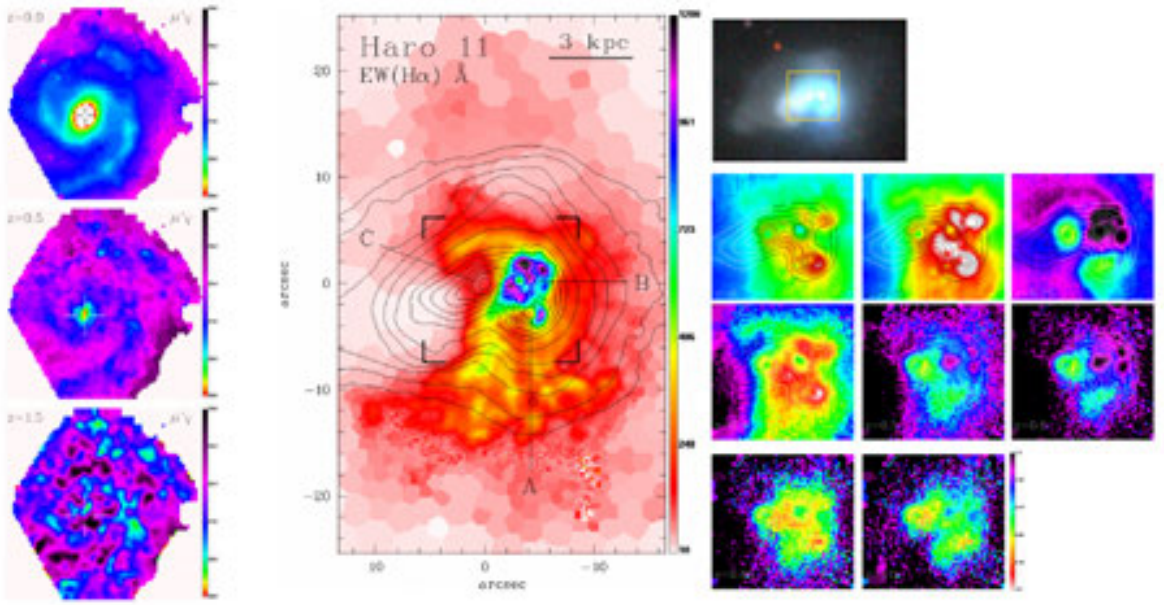


Fig. 4: left: Synthetic V-band images of the local spiral galaxy NGC 0309 simulated at a redshift z=0, 0.5 and 1.5. It can be appreciated that the prominent bulge of this system becomes virtually absent at z=1.5. middle: Hα equivalent width map of the nearby BCD Haro 11, documenting a starburst-driven gas outflow on spatial scales of 10 kpc away from the center of the galaxy. right: True-color image of Haro11 (uppermost panel) and simulated V-I color maps of the galaxy out to z=1 (lower panels). It can be seen that the color morphology drastically changes with redshift as a result of intrinsic stellar age gradients in the BCD and the photometric effect of strong emission lines (from Papaderos, Östlin & Breda 2022, A&A, submitted).

The starting point of this study is that the shift of the rest-frame UV into the observer's frame (ObsF) visual leads to the enhancement of the surface brightness of the UV-bright disk relative to UV-faint bulge. This differential effect is referred to by the above mentioned researchers as chromatic surface brightness modulation (CMOD). As they showed, CMOD introduces a strong discrepancy between true (rest frame) and ObsF morphology, structural properties and colour patterns in higher-z galaxies, and this bias is further amplified by intense nebular emission lines entering into different photometric filters, depending on the redshift of a galaxy.

This study has quantified the CMOD effects using both evolutionary synthesis models for mock two-component (bulge+disk) galaxy models simulated out to z=3 and with spatially resolved population synthesis models for galaxies with observed IFS data.
Two of the main results from this study were that a) galaxies at z~1 with an old, passively evolving bulge appear in optical broadband images as almost bulgeless disks, and b) the effective radius, which is commonly used to measure the size evolution of galaxies is not robust against the CMOD effect.

Group meetings, Journal Clubs and other activities:

With the gradual decline of the COVID19 pandemic, the team has started resuming its normal work mode while maintaining regular internal communication via video conferencing. In 2022, the team significantly increased its productivity, further intensified internal synergies, and established new collaborations.

Throughout 2022, the team maintained a busy schedule of weekly Briefings to discuss its scientific work. In addition, the regular weekly journal clubs continued, where the latest scientific results, mostly non-IA, were discussed.
Furthermore, the team organized a two-day internal workshop (Coimbra, 28 and 29 November 2022) to discuss ongoing research and its key strategic goals for the coming years.

The dynamism of the team is also reflected in the continued development and intensive testing of Machine Learning and spectral fitting tools that will strongly support its scientific activities in the context of Euclid, MOONS@VLT, MOSAIC@ELT and BlueMUSE@VLT, as well as the organization of the conference “Escape of Lyman radiation from galactic labyrinths” to be held in Crete, April 18-21, 2023.

Polychronis Papaderos
Group Leader

Report from the Group

Unveiling the dynamics of the Universe

This report highlights contributions in the main subjects of research in the cosmology group, centering around dark energy, modified gravity and cosmic defects. We focus essentially on the Euclid, ESPRESSO and LISA missions.

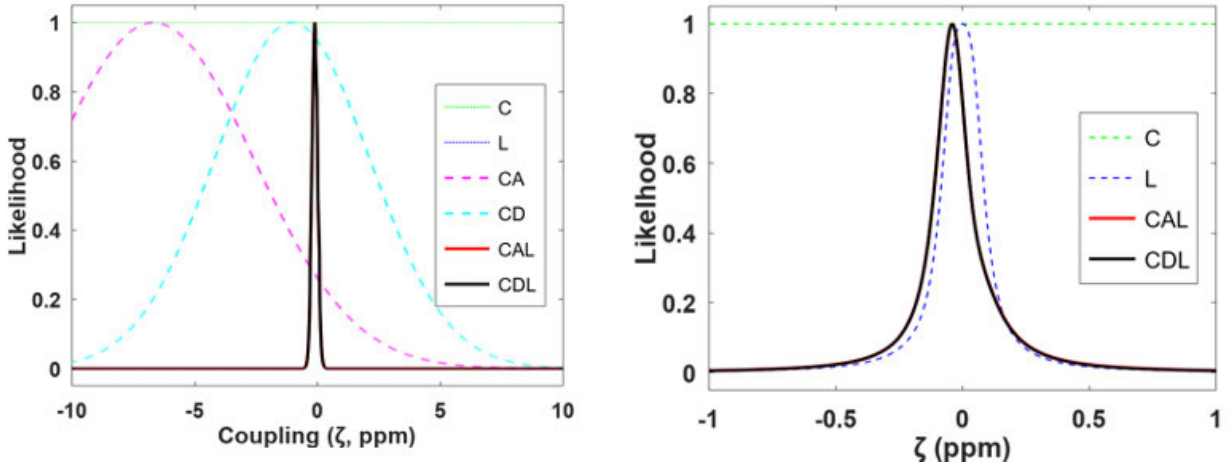
Euclid is a mission dedicated to the exploration of the dark universe through the measurement of the properties of the cosmological large-scale structure. IA is strongly involved in this mission, participating in the consortium board, in various Science Working Groups and in the Survey Design. Several members of the IA cosmology group have participated as lead-authors in key and standard papers published in 2022. One of our members is deputy of the Euclid Survey Working Group and the Survey Model owner having organized the Euclid survey working group meeting in October 2022 at FCUL.

The ESPRESSO spectrograph is an instrument of interest to several groups in IA. For cosmology, its main interest lies in the possibility of measuring variations of the fundamental constant. Following from last year, three papers with several IA members as co-authors were published in 2022 on using ESPRESSO to place constraints on the variation of the fine-structure constant and on models of dark energy with couplings to the electromagnetic fields.

LISA will be a large-scale space mission designed to detect gravitational waves. The LISA cosmology white paper is in the final stages of publication. This has the contribution of several IA members, with one member having the coordination of the cosmic strings section. Work was also done on the development of the LISA template for cosmic string signals that is in the final stages of development.

Scientific Highlights for 2022

Constraints on Bekenstein and dark energy models from ESPRESSO



Constraints on electromagnetic coupling of the Bekenstein (left) and parametrized quintessence (right) dark energy. The dashed lines relate to the following data: Cosmology only (C), Local only (L), Cosmology+Archival+Local (CAL), Cosmology+Dedicated+Local (CDL).

Models of dark energy with dynamical scalar fields can naturally couple to the electromagnetic sector, in particular leading to variations on the value of the fine-structure constant. In a paper published this year, "Fundamental physics with ESPRESSO: Constraints on Bekenstein and dark energy models from astrophysical and local probes", Phys. Rev. D 105 (2022) 12, 123507 (doi: 10.1103/PhysRevD. 105.123507), ESPRESSO measurements of α, together with measurements from other contemporary cosmological and local probes, stringent constraints were placed on two broad classes of models: Bekenstein models and quintessence-type dark energy models. Both of these can also be seen as parametric extensions of the standard ΛCDM model. Local measurements have improved previous results by an order of magnitude, and the single ESPRESSO measurement was shown to be competitive with the other present cosmological probes. Several team members are authors in this paper, with one member being the main author.

Euclid: Forecast constraints on consistency tests of the ΛCDM model

An observational violation of spatial homogeneity or isotropy on very large scales is a direct consistency test of the ΛCDM model. The paper "Euclid: Forecast constraints on consistency tests of the ΛCDM model", Astron. Astrophys. 660 (2022) A67 (doi: 10.1051/0004-6361/202142503), has quantified the ability of the Euclid mission, together with contemporary surveys, to improve the current sensitivity of null tests of the canonical cosmological constant Λ and ΛCDM model in redshifts up to 1.8. The study was carried out for a ΛCDM fiducial model, a dark energy CPL parametrized model and an inhomogeneous ΛLTB model. The analysis was done with a machine learning reconstruction method based on genetic algorithms and, alternatively, a theory-agnostic parametric model based on Taylor expansion and data binning. It was found that Euclid, together with external probes, will be able to improve current constraints by approximately a factor of three using the machine learning methods, and a factor of two with the parametric approach. Furthermore, the parametric approach was found to introduce possible biases for some models removed from ΛCDM. This paper was co-written with several cosmological group members.

Cosmology in scalar-tensor f(R, T) gravity

Modified gravity based on f(R, T) models can be cast in a scalar-tensor representation. The paper "Cosmology in scalar-tensor f(R, T) gravity", Phys. Rev. D 105 (2022) 6, 064019 (doi: 10.1103/PhysRevD.105.064019) used this to reconstruct the possible forms the scalar field can take in a FLRW background with a perfect fluid. Explicit forms of the f(R, T) models associated were also obtained from the results. This paper has the authorship of two members of the cosmology group.

Designer approach to f(Q) gravity and cosmological implications

Symmetric Teleparallel Gravity, in particular f(Q) models, is a subject with several group members actively involved. One such example is the paper "A designer approach to f(Q) gravity and cosmological implications", Phys. Dark Univ. 35 (2022) 100980 (doi: 10.1016/j.dark.2022.100980), where the linear perturbations of f(Q) models built to mimic specific expansion histories were investigated. In particular, the paper produced the computation of the growth rate, σ8 and the sign of the cross-correlation power spectrum between galaxy fluctuations and the CMB radiation anisotropies. Eventually with accurate cosmological observations, these observables will be able to distinguish f(Q) gravity from similar expansion histories in standard gravity. This paper was co-authored by one of our PhD students.

Group meetings, Journal Clubs and other activities

The cosmology group held fourteen IA seminars in 2022, some of them online.

The group also had regular weekly journal club meetings. In total the group held 32 “CosmoClub” meetings. These are in person in both nodes with an online zoom connection. Every week we have a general discussion, and a different team member brings one paper (or more) for discussion. Details can be found in http://ia-cosmoclub.wikidot.com/.

The cosmology group also organized COSMONATA, the annual meeting in late December bringing together Portuguese researchers working abroad with researchers in Portugal.

Team members were also actively engaged throughout 2022 in several outreach activities, including talks given in schools. Most of these activities are developed with the Science Communication Team.

Two students of the cosmology team successfully completed their PhD thesis in 2022

Tiago Barreiro
Group Leader

Report from the Group

Astronomical Instrumentation and Systems

The year 2022 brought the normality after the previous limitations caused by the pandemic situation. For the Astronomical Instrumentation and Systems Group (AISG), this represented an extra effort caused by the pressure to conclude running projects that were delayed and to start new projects that were postponed.
As seen in this report, there was significant progress during this year, achieving some important milestones in several projects and starting promising future ones.

During 2022, the following instruments had engineering and implementation activities at IA:

- For the European Southern Observatory (ESO): NIRPS, MOONS, ANDES, BlueMUSE and PoET.
- For the European Space Agency (ESA): EUCLID, CHEOPS, PLATO, ARIEL and ATHENA.

Currently the AISG participates in a considerable number of projects, involving all its human resources. This includes not only the technical design of the instruments themselves but also the respective science exploration of the collected data through big collaboration projects such as consortiums and surveys. Its importance stems from the need to secure privileged access to existing and future facilities of the European Organization for Astronomical Research in the Southern Hemisphere (ESO) and of the European Space Agency (ESA) and to contribute to the long term development of Astronomy in Portugal.
In terms of Human Resources, the group was left without a Mechanical Engineer (Pedro Nunes dos Santos), which is now one of the priorities in terms of reinforcements for the team, and saw the return of a researcher (David Alves).

In terms of new themes of research, somehow supported by background expertise in Astronomy Instruments / Space missions and consolidated by the work PhD students supervised by AISG researchers, the team is exploring:

a. Stabilization of calibration light sources for High Accuracy Photometry Instruments resulting from research and develop a device that senses the light source fluctuations and modulates the beam, both in flux and in spectra, to produce a sufficiently stable source, a truly impressive challenge when stabilization levels of few ppm are required over long periods of observation.
b. Discovery and characterization of temperate Earth-like worlds with ESPRESSO, with a main goal to improve the radial velocity extraction from the ESPRESSO science data. This is a module to be attached to the Data reduction pipeline of ESPRESSO. This thesis is more focused on the analysis of M stars which are trickier to get precise and stable radial velocities for the detection of exoplanets, but at the same time are the more promising targets to find earth-like in the habitable zone.
c. Development of a solar telescope that will allow the detailed study of the Sun (using it as a proxy to understand the sources of noise that affect the observations of other stars). For that, it is fundamental to be able to obtain disk-resolved, HR spectra, opening a whole new path for the detection and characterization of Earth-like planets orbiting other Suns.

d. Development of miniaturized Cross dispersed echelle spectrographs operating in the VIS and UV with the Size Weight and Power (SWaP) requirements for a SmallSat solution and the required spectral resolution to allow the study of this less explored spectral range.
e. Study of space debris detection algorithms in a standalone platform, with the goal to implement and test a star tracker that can be used for space debris detection. The methodological approach consists of selecting the most appropriate debris detection algorithms, adding automatic photometry measurements, developing a standalone platform, implementing the algorithms in the platform, selecting the low-cost materials capable of withstanding the harsh space environment, and optimizing the algorithms to work in different scenarios.

Following is listed the activity detail of the running projects.

1. NIRPS (ESO)

NIRPS is a new (fast-track instrument) high resolution spectrograph working at near-infrared bands, that is being designed for the ESO 3.6-m telescope (La Silla-Paranal Observatory). NIRPS will work together with the existing HARPS spectrograph, allowing us to obtain simultaneous optical and near-IR spectra of stars. The major goal of NIRPS is to detect and characterise planets orbiting late type stars. The NIRPS consortium includes a strong participation from IA, including in the development of hardware and software (the Atmospheric Dispersion Correctors - ADC), and in the definition of scientific activities.
2022 was the year where the instrument had a successful first light for science. The participation of the Group is now concluded and the effort was now passed to the scientific groups for the instrument exploitation.

2. MOONS (ESO)

The Multi-Object Optical and Near-infrared Spectrograph (MOONS) is a future third-generation instrument for the Very Large Telescope (VLT) to have first light by 2023. It matches an enormous multiplexing capability, reaching up to 1000 positions being spectroscopically observed at the same time over a single telescope pointing to the grasp of the 8.2m VLT, making it a unique instrument for deep galaxy surveys.
The subsystems under IA responsibility are the MOONS Rotating Front End (RFE) and the Field Corrector (1 m diameter set of two lenses).
2022 saw two important milestones in this project. The first was the delivery of the RFE system to UKATC in Scotland for the final test and integration of all the subsystems in charge of the other partners in the consortium. A first mission was held in September to test the RFE at UKATC premises, work to be followed during 2023 towards the Preliminary Acceptance in Europe.
The second milestone was the installation in Paranal, in October/November, of the field corrector. The corrector was also commissioned and had a successful first light. The system is now waiting for the observatory for the remaining parts of the instrument.

Figure: The MOONS (ESO) Field Corrector being installed in the ESO Paranal observatory.

Figure: The MOONS (ESO) RFE during tests in the UKATC facilities (Edinburgh, Scotland).

3. ANDES (ESO)

ANDES, formerly known as HIRES, is the project for a high resolution spectrograph to be installed at the ESO E-ELT telescope. The concept of ANDES is being developed by a consortium that comprises several institutes in different European countries, as well as USA, Canada, Brazil and Chile. The Portuguese participation in this consortium is done through IA that is leading the “front end” workpackage component of the instrument, the data reduction and analysis software, the software system architecture, and the science drivers for the project. The group also participates in the management of the consortium, having several key persons.

After the finishing of the Phase A studies in 2017 and the Pre-phase B activities of 2021, 2022 saw the start of the Phase B in the final quarter of the year.

4. BlueMUSE (ESO)

BlueMUSE is a blue-optimised, medium spectral resolution, panoramic integral field spectrograph that is planned for the Very Large Telescope (VLT) with first light foreseen for 2030. BlueMUSE builds on the heritage of the MUSE integral field spectrograph, the currently most oversubscribed instrument on the VLT, and IA is a member of the consortium to build the instrument led by Lyon. The BlueMUSE project had their Gate 0 kick-off meeting in Nov/Dec 2022. The IA contribution to the project will be in the area of control software and electronics.

5. PoET (ESO)

The detection and characterisation of other Earths, planets with the physical conditions to hold liquid water and thus potential life-sustaining environments, is a bold objective of present day astrophysics. This quest is however severely challenged by astrophysical “noise” from the host stars. To address this problem we started in 2022 a new project to build a dedicated facility, the Paranal Solar Espresso Telescope (PoET). This telescope will be linked to the ESPRESSO spectrograph (ESO) and allow simultaneous acquisition of disk-integrated (sun-as-a-star) and arcsecond level disk-resolved observations of the Sun at a spectral resolution R~200000. The project is funded by the European Union (ERC, FIERCE, 101052347). And it is a Portuguese project.
The project kicked-off in the last quarter of 2022, it is in its preliminary design phase and already has a mission to Paranal (October 2022) to organise with ESO the interface questions with the Observatory.

6. EUCLID (ESA)

Euclid is ESA's mission dedicated to the exploration of the dark universe through the measurement of the properties of the cosmological large-scale structure. IA is strongly involved in this mission, participating in the consortium board, in various science working groups, and in the Survey Design, which is an activity of support to the Euclid Consortium Lead.
In 2022, IA's Instrumentation and Systems Group continued its long-standing participation in the preparation of the Survey Design, focusing on the development of the ECTile software. This software computes the mission's Reference Survey, i.e., it produces schedules of the Euclid Deep and Wide surveys, including implementation of all calibrations, compliant with all constraints and requirements. This year further consolidated the development of the survey generating tool. Many internal aspects were improved and/or corrected, consolidating ECTile as a future operational tool. Plus, a new tool was implemented for the computation of Wave Front Error campaign (WFE). This tool purposefully implements an incomplete schedule, determining all possible starting times, serving as an initial analysis tool on the viability of WFE campaigns. Also, a tool was implemented to compute patches on the thermal stabilisation periods of the WFE campaigns, where the spacecraft attitude is strongly constrained.
Complementary to the ECTile development, a grand total of eight surveys were generated this year. The first 4, RSD2022A to RSD2022D, were generated to test various scenarios, delivered in time for the Mission Key-point Review, held in January 2022.

The remaining surveys were generated to test some envisaged scenarios like extending the survey one more year and accommodate a major change in the Region-of-Interest. Of these, the RSD2022G is the most notable one, incorporating significant new parameters like the “as-built” FoV, the latest slew parameter calculator, and a reduction of SOPS (maintenance stops) to 6 hours. The incorporation of these parameters made the survey generation one big step closer to an operation survey.

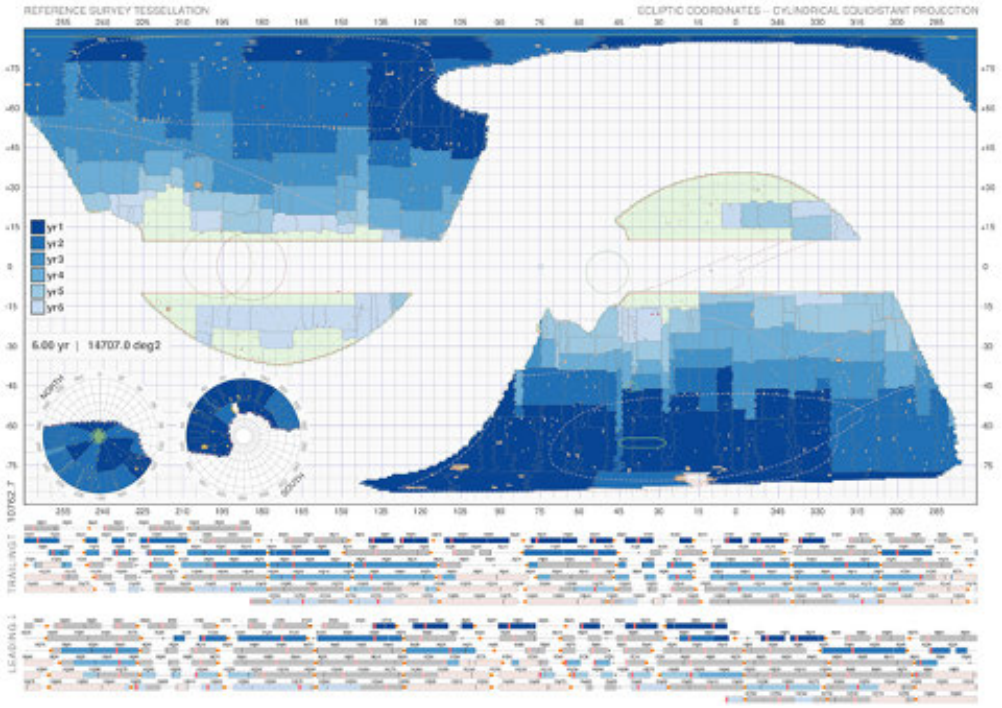


Figure: The year by year footprint of RSD2022G Euclid Reference Survey. The Region-of-Interest is depicted in light green (not all scheduled for observation).

As referred above, most of the activities focus on consolidating the ECTile tool and surveys generation, with an increased pace once the launch date was set to July 2023.

7. CHEOPS (ESA)

The Characterising Exoplanet Satellite (CHEOPS) is the first mission dedicated to search for transits of exoplanets by means of ultrahigh precision photometry on bright stars already known to host planets. It will provide the unique capability of determining accurate radii for a subset of those planets for which the mass has already been estimated from ground-based spectroscopic surveys. CHEOPS will also provide prime targets for future instruments suited to the spectroscopic characterization of exoplanetary atmospheres. IA is strongly contributing for this mission participating both in the board and the core science team of the mission. This work is also closely related with the science data archive which is being developed by our industry partners (DEIMOS), contributing to the development of stronger relations with the Portuguese industry in the area of scientific related software.
Moreover there is a contribution for the mission science operation centre, more specifically for the CHEOPS data reduction pipeline where we are responsible for the calibration of the pipeline.
In 2022, CHEOPS continued to run well within specifications and continued to get scientific observations of high precision. IA continued to give maintenance support to the data reduction pipeline during the CHEOPS mission. During 2022, the CHEOPS consortium has coordinated and submitted

the proposition to ESA for the extension to the mission. For the extension we were proposed to take the lead of the maintenance of the Data Reduction Pipeline replacing the team from LAM France which was in charge of this job during the nominal mission with our active participation. To go forward with this very good opportunity we also started discussions with PTSpace to access funding through Prodex. The proposal was submitted for funding at the end of 2022.

8. PLATO (ESA)

The PLATO mission, whose main scientific focus is the detection and characterization of extra-solar planets orbiting nearby, bright stars, using the transit method, as well as the detailed characterization of their host stars through asteroseismology, has been adopted by ESA in June 2017. The instrumentation team has leadership of several work packages for the development of software for the Plato Data Center (PDC) as well as in the development of the Optical Ground Segment (OGSE) component to test and calibrate the PLATO cameras on ground.

Regarding the contribution to the OGSE, and during the year of 2022, the team integrated and tested the second collimator, which was delivered to CSL (Be). This collimator was commissioned in July 2022, with the presence of two elements of the IA-Instrumentation team at CSL. During the same mission, the first collimator on site was also serviced, with the substitution of some electronic parts that were not working correctly.

At the end of the second trimester of 2022, ESA contacted us for the production of a third OGSE to be provided directly to ESA headquarters at Nordjwick. A contract was celebrated between ESA and IA-Lisbon to this purpose. The delivery date for this item is June 2023.

Figure: PLATO (ESA) being assembled at CSL premises (Liege, Belgium).

9. ARIEL (ESA)

ARIEL (Atmospheric Remote-sensing Exoplanet Large-survey) was one of the three candidate missions selected by the European Space Agency (ESA) for its next medium-class science mission due for launch in 2028. The goal of the ARIEL mission is to investigate the atmospheres of several hundred planets orbiting distant stars in order to address the fundamental questions on how planetary systems form and evolve.

The main activities of IA – instrumentation in ARIEL and together with the OGSE team led by Oxford University, were associated to the design of part of OGSE system, associated to the illumination module and reference detector subsystem working in the Visible /Near Infrared part of the spectrum. The reference detector function is to monitor the light source fluctuations and to provide source stability data required to detrend the results from the ARIEL instruments when operating in vacuum and cryo conditions.

During the year of 2022, a preliminary design for the VISNIR OGSE was produced. The illumination module was defined and several lab tests were produced to verify system performance in terms of stability, flux and spectral characteristics.

A major effort was also initiated regarding the design and testing of the reference detector that must operate at 70K. During 2022 more than 400 hours of cryo and vacuum cycles were produced in order to test performance of both the detectors and the pre-amplifier solutions. Results obtained until the end of 2022 allowed to confirm and narrow down the several solutions tested, which are performing within the expected requirement limits.

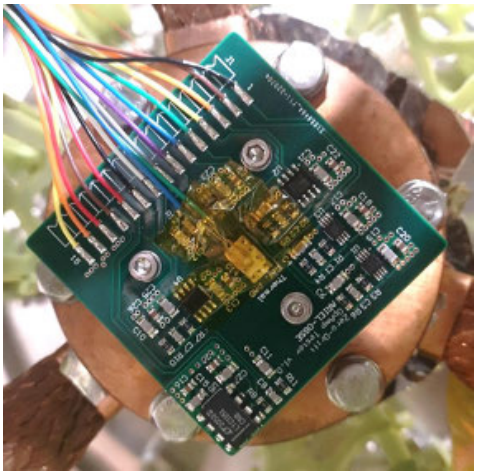


Figure: Ariel OGSE electronics at cryogenic tests.

10. ATHENA (ESA)

The group of Instrumentation of IA is leading the international consortium for the development of the Athena mission on-board metrology system, in the sequence of the approval of activity proposal to the ESA tender, which had the kick off in June 2020.

The function of the system being developed by the team is measuring the exact pointing of the Athena mirror during the process of switching focus between the X-IFU and WFI Athena instruments. The level of accuracy required for this task is at the level of a fraction of an arcsecond.

During the year of 2022 we had to perform a series of adaptations to the design due to the re-definition of some requirements associated with the OBM performance and test conditions.

Most of these modifications were associated with the impossibility of supporting, at system level, certain aspects regarding the proposed design solution. These were related mainly to the definition of location and mount criteria for the fiducials, at the Athena instrument level, due to different development phases on the instrument side. The solution was to assume a reference case, similar to the WFI case, with respect to which the OBM performance verification shall be made.

The PDR milestone was successfully achieved at the beginning of 2022 and the procurement and production of the several parts of the OBM system was initiated.

System tests are expected to occur in May 2023.

Highlights for 2022

1. The installation of the MOONS Field Corrector in ESO Paranal Observatory.
2. The beginning of the PoET project, a Portuguese instrument to be installed in ESO Paranal Observatory.
3. ESA issued a new direct contract to build a third Plato OGSE.
4. Athena OBM passed the Detailed Design Review and started production.

Alexandre Cabral
Group Leader

Report from the Group

Science Communication

The first two months of 2022 were still marked by the COVID-19 Pandemic. Schools were still closed and many public events were cancelled and all cultural venues were forced to reduce their capacity. This caused an impact on the IA Science Communication Group (SCG) activity.

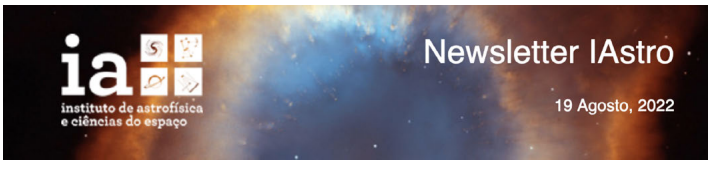
During 2022 the SCG organised and participated in several public Science Communication initiatives which reached a total of about **76 000 people**.

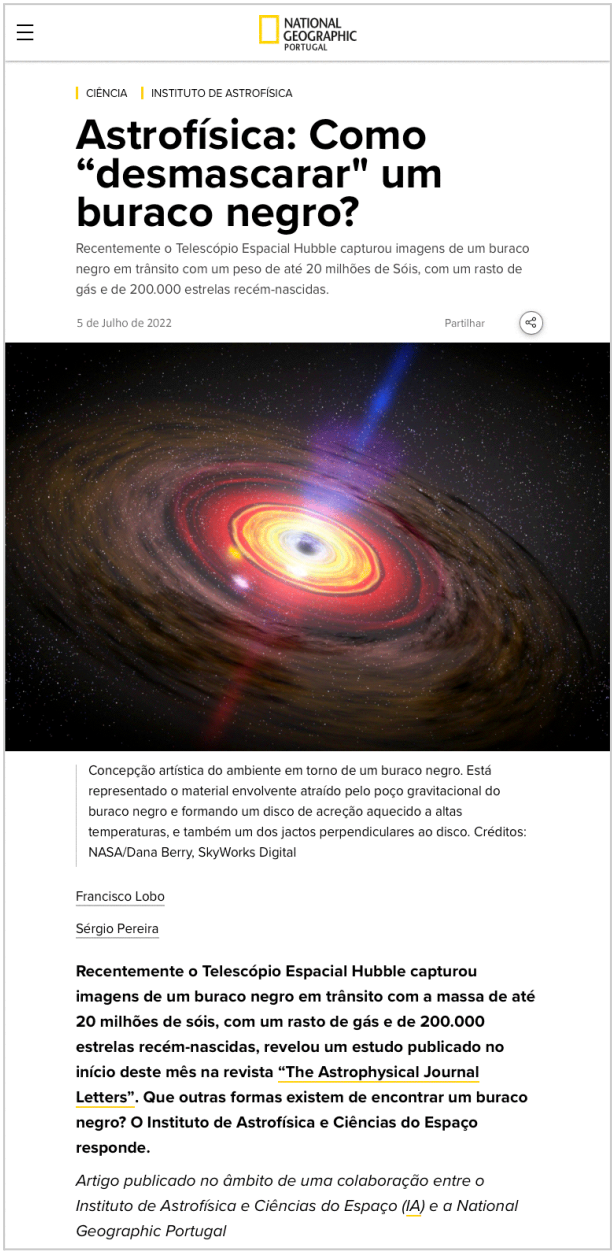
Public activities directly organised by IA reached about **60 000 people**. These activities include, among others, planetarium shows, monthly periodic outreach sessions, exhibitions, showcases, hands-on laboratories and special public events and talks. The SCG team has also participated in several initiatives promoted by other institutions, such as Ciência Viva, the Museums of the University of Lisbon and many schools, contributing also with talks, observations of the night sky, planetarium shows, exhibitions, showcases, workshops and short courses, reaching about **16 000 people**.

The SCG has been responsible for the creation of the exhibition "ESPRESSO – An Adventure in the Atacama Desert" which reveals the adventure that was the accomplishment of the ESPRESSO spectrograph, from its development to its installation in the Atacama Desert, in Chile, as well as the scientific challenges and results to which it is contributing. It is the account of part of that adventure, in photographs and memories, created in the driest desert in the world, in Chile, that two of those pioneers, Alexandre Cabral and Nuno Cardoso Santos, offer in this exhibition and in a book. The book was launched at two events, held in Lisbon in May (Faculdade de Ciências da Universidade de Lisboa) and Porto in July (Planetário do Porto).

IA maintains its strong presence in social media, with 9554 followers on Facebook, 754 on Twitter, 1222 on Instagram and 2324 on Youtube. The group has produced 316 publications on Facebook, 228 on Twitter and 2304 on Youtube. These numbers of (unpaid) publications resulted in a total reach of more than **283,500 people** (unique users)**.**

IA now has **4396 subscribers** of the monthly IAstro Newsletter, a 8.8% increase over the number of subscribers in 2021. In total, IA sent **17 newsletters in** 2022.





NATIONAL GEOGRAPHIC PORTUGAL

CIÊNCIA | INSTITUTO DE ASTROFÍSICA

Astrofísica: Como "desmascarar" um buraco negro?

Recentemente o Telescópio Espacial Hubble capturou imagens de um buraco negro em trânsito com um peso de até 20 milhões de Sóis, com um rasto de gás e de 200.000 estrelas recém-nascidas.

5 de Julho de 2022 Partilhar

Concepção artística do ambiente em torno de um buraco negro. Está representado o material envolvente atraído pelo poço gravitacional do buraco negro e formando um disco de acreção aquecido a altas temperaturas, e também um dos jactos perpendiculares ao disco. Créditos: NASA/Dana Berry, SkyWorks Digital

Francisco Lobo

Sérgio Pereira

Recentemente o Telescópio Espacial Hubble capturou imagens de um buraco negro em trânsito com a massa de até 20 milhões de sóis, com um rasto de gás e de 200.000 estrelas recém-nascidas, revelou um estudo publicado no início deste mês na revista "The Astrophysical Journal Letters". Que outras formas existem de encontrar um buraco negro? O Instituto de Astrofísica e Ciências do Espaço responde.

Artigo publicado no âmbito de uma colaboração entre o Instituto de Astrofísica e Ciências do Espaço (IA) e a National Geographic Portugal

The SCG produced **4 articles** (written for the public) for National Geographic Portugal and SAPO Tek websites. This increases the visibility of IA since, for example, SAPO Tek reaches about 2 million people. In 2022 the SCG also created several media contents, such as Youtube videos, and contents for its official webpage.

The SCG team produced and made available to the media **13 press releases** (13 national and 2 of them also international) related to the science produced by IA or to its outreach activities. This number of press releases resulted in about **492** references in national news media with a total Automatic Advertisement Value (AAV) of about **€ 3 378 071,70.** We also made available through our webpage and partners, **9 news releases**.

IA has been mentioned by international news media, for example: **Forbes**, **Scientific American** and **The Atlantic**.

The science communication and education work at IA has been presented in national and international conferences with invited and contributed talks and workshops – 9 invited talks, 8 invited workshops and 3 contributed talks. The conferences include, among others, the Europlanet Funding session, the 4th Shaw-IAU Workshop on Astronomy for Education and the Congresso Internacional Escola, Identidades e Democracia. The team is responsible for several articles for monthly columns.

The SCG has supervised a total of **36 bachelor and master students** from several faculties and universities, including Faculdade de Ciências Sociais e Humanas da Universidade Nova de Lisboa, Faculdade de Belas Artes da Universidade do Porto, Universidade Lusófona, Faculdade de Ciências da Universidade do Porto and Politécnico do Porto – Escola Superior de Educação.

The IAstro Summer Internships are a three-week IA program to give university students a first contact with the research done at IA, as well as training in science communication. The 2022 edition offered a total of **21 projects** and **three** science communication **workshops**, involving **22 researchers**. A total of **185 applications**

were received and **69 students** participated in the training, from **39 different universities** from Portugal, Brazil, United Kingdom, Austria, Italy, India, Mexico, Mozambique, USA and Bolívia.

During 2022, the SCG has conducted several training sessions for teachers, science communication officers, students and the non-specialist public.

The SCG is responsible for the creation and development of several national projects like Ler+Espaço, Ignite IAstro Tour and CoAstro:@n Astronomy Condo. IA also participated in the Cientificamente Provável programme, a partnership by the Portuguese Government, implemented through the network of school libraries, and in the Clubes Ciência Viva na Escola, a Ciência Viva project, partnering with **112 schools**.

IA provides the scientific management of the Planetário do Porto CCV activities, all of which are developed, organised and implemented by members of IA's SCG, having reached in 2022 **54,430 people** through fixed domed and portable planetarium sessions, hands-on laboratories, online activities and special initiatives.

At the end of 2022, a memorandum was signed strengthening the already existing synergy between IA and the Office for Astronomy Outreach of the International Astronomical Union (IAU-OAO), the largest international organisation in astronomy. With the signing of a memorandum, this collaboration paves the way for more international projects with Portuguese (IA) collaborations. This synergy looks to expand the production of contents and tools for the communication and teaching of astronomy. One of the components of this collaboration will be the involvement of IA at the editorial level in IAU's international peer-reviewed journal of astronomy communication, Communicating Astronomy with the Public (CAPiournal), in which IA will figure as official partner.

IA co-leads, together with the Leiden Observatory/ University of Leiden, the development of an international Astronomy Literacy Project, which aims to define global astronomy education goals to be applied in worldwide school curricula. "**Big Ideas in Astronomy: A Proposed Definition of Astronomy Literacy**" booklet, the first global Astronomy Literacy document, is the first outcome of this project. The second version of this document is available as a booklet in 10 languages, including Portuguese, and is globally available on a dedicated website of the International Astronomical Union's Office of Astronomy Education (OAE).

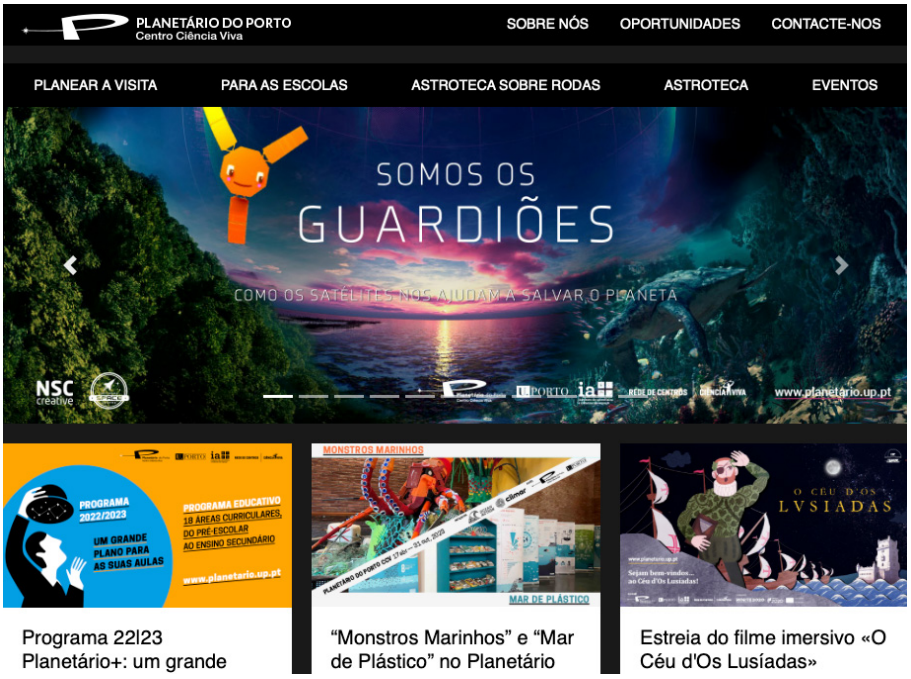
IA continues with a strong involvement with the "Portuguese Language Expertise Centre for the Office of Astronomy for Development (of the International Astronomical Union)" – PLOAD. It is hosted by Núcleo Interativo de Astronomia (NUCLIO), in collaboration with IA. The PLOAD's main objectives are to establish a strong collaborative network between Portuguese speaking countries and communities and empower these countries and communities with the

PLOAD
Grupo Lusófono de **Astronomia** para o Desenvolvimento

necessary tools to build their own local support structures and strategy development in Astronomy and Space Sciences.

The strategy of the SCG for the 2022-2023 period is to strengthen its position as a player in global astronomy communication, development and education projects. The SCG also aims at amplifying the reach and impact of its communication and education contents through several synergies, specially with the partnership established with IAU-OAO, and to guarantee national investment in astronomy research and education through policy making.

IA will continue implementing public engagement activities, and the production of Astronomy related educational and science communication contents for several specific target audiences, with a special focus on students and teachers. This production is strengthened by the involvement in the “Astronomy Literacy” international project and the official partnership with IAU-OAO. These contents can exist by themselves or be produced with specific uses such as planetarium sessions, hands-on activities or exhibitions. In this context, the management of the Planetario do Porto is important to project the IA to society and provide human resources for the group. The production of these materials places IA as the main institution in Portugal in terms of the production of Astronomy related contents. IA’s strong involvement in the PLOAD allows the dissemination of its contents throughout the Portuguese language countries which engulfs 240 million people.



Programa 22|23 Planetário+: um grande

“Monstros Marinhos” e “Mar de Plástico” no Planetário

Estreia do filme imersivo «O Céu d'Os Lusíadas»

João Retrê and Filipe Pires
Group Lead

Scientific Output

Books [2]

1. M. Hindmarsh, **A. R. Liddle**, 2022; *Introducing General Relativity*; Wiley
2. **C. J. A. P. Martins**, 2022; *A História do Universo - A Nossa Visão Actual e como Chegámos a Ela*; Edições 7

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2. N. Seymour, G. Drouart, G. Noirot, J. W. Broderick, R. J. Turner, S. S. Shabala, D. K. Stern, S. Bellstedt, S. P. Driver, L. Davies et al. (*including:* **J. Afonso**), 2022; *HST WFC3/Grism observations of the candidate ultra-high-redshift radio galaxy GLEAM J0917–0012*; Publications of the Astronomical Society of Australia, 39
3. I. H. Whittam, M. Jarvis, C. L. Hale, M. Prescott, L. Morabito, I. Heywood, N. Adams, **J. Afonso**, F. An, Y. Ao, 2022; *MIGHTEE: the nature of the radio-loud AGN population*; Monthly Notices of the Royal Astronomical Society, 516, 1, 245
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17. A. Marconi, **M. Abreu**, **V. Zh. Adibekyan**, V. Alberti, S. Albrecht, J. Alcaniz, M. Aliverti, C. Allende Prieto, J. D. Alvarado Gómez, P. J. Amado et al. (*including:* **S. C. C. Barros**, **A. Cabral**, **O. Demangeon**, **J. P. Faria**, **C. J. A. P. Martins**, **M. A. Monteiro**, **N. J. Nunes**, **P. Papaderos**, **N. C. Santos**, **S. G. Sousa**, **B. Wehbe**); 2022; *ANDES, the high resolution spectrograph for the ELT: science case, baseline design and path to construction*; Ground-based and Airborne Instrumentation for Astronomy IX; (Eds.)Christopher J. Evans; Julia J. Bryant; Kentaro Motohara, SPIE, Proceedings of the SPIE, 12184
18. M. Martinelli, **C. J. A. P. Martins**, S. Nesseris, I. Tutusaus, A. Avgoustidis, A. Blanchard, S. Camera, C. Carbone, S. Casas, S. Ilic; 2022; *Testing fundamental cosmological assumptions with Euclid*; 17th edition of the International Conference on Topics in Astroparticle and Underground Physics, IOP, Journal of Physics: Conference Series, 2156, 1
19. V. Miranda, **P. Pina**, S. Heleno, S. Hong, H. Lee, G. Vieira; 2022; *Assessment of Antarctic Vegetation Classification as a Function of the Spatial Resolution (Barton and Weaver Peninsulas, King George is)*; IGARSS 2022 - 2022 IEEE International Geoscience and Remote Sensing Symposium, IEEE
20. E. Pace, A. Tozzi, **M. Abreu**, G. Alonso, B. Barroqueiro, G. Bianucci, A. Bocchieri, D. Brienza, A. Brucalassi, M. Burresi; 2022; *The telescope assembly of the Ariel space mission*; Space Telescopes and Instrumentation 2022: Optical, Infrared, and Millimeter Wave; (Eds.)Laura E. Coyle; Shuji Matsuura; Marshall D. Perrin, SPIE, Proceedings of the SPIE, 12180
21. **C. P. Pereira**, **M. Abreu**, **A. Cabral**, **J. M. Rebordão**; 2022; *Characterization of Light Diffraction by a Digital Micromirror Device*; Fifth International Conference on Applications of Optics and Photonics; (Eds.)Manuel Filipe Pereira da Cunha Martins Costa, IOP, Journal of Physics: Conference Series, 2407, 1
22. J. L. Rosa, J. P. S. Lemos, **F. S. N. Lobo**; 2022; *Wormhole solutions in generalized hybrid metric-Palatini gravity*; The Fifteenth Marcel Grossmann Meeting; (Eds.)Elia S Battistelli; Robert T Jantzen; Remo Ruffini, World Scientific Publishing Co. Pte. Ltd., 588
23. F. Wildi, F. Bouchy, R. Doyon, N. Blind, L. Genolet, M. Sordet, A. G. Segovia Milla, N. Grieves, L. Malo, E. Artigau et al. (*including:* **A. Cabral**); 2022; *First light of NIRPS, the near-infrared adaptive-optics assisted high resolution spectrograph for the ESO 3.6m*; Ground-based and Airborne Instrumentation for Astronomy IX; (Eds.)Christopher J. Evans; Julia J. Bryant; Kentaro Motohara, SPIE, Proceedings of the SPIE, 12184

International Scientific Communications [141]

1. **M. Abreu**, **A. Cabral**, **J. M. Rebordão**, N. M. Gonçalves, S. Mottini, J. Costa Pinto, D. Silva, **J. Afonso**, **I. Matute**, D. Oddenino; 2022; *Optical on-board metrology in the Athena x-ray mission*; SPIE Astronomical Telescopes + Instrumentation, 2022, Montréal, Québec, Canada
2. **V. Zh. Adibekyan**; 2022; *Understanding planets through their host stars in the eyes of PLATO*; PLATO WP122 Liège workshop #5, Liege, Belgium
3. **V. Zh. Adibekyan**; 2022; *The Chemical link between stars and their rocky planets*; CHEOPS Science Workshop VI, Online, Switzerland
4. **V. Zh. Adibekyan**; 2022; *Composition of super-Earths, super-Mercuries, and their host stars*; Forming and Exploring Habitable Worlds, Edinburgh, Uk
5. **V. Zh. Adibekyan**; 2022; *Diversity of terrestrial planets: a link to the chemical makeup of their host stars*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
6. **J. Afonso**; 2022; *Key Science Project 8: Radio AGN in the EoR*; Evolutionary Map of the Universe International Virtual Meeting, Online, Australia
7. **J. Afonso**, **D. D. Barbosa**, **R. Carvajal**, **I. Matute**; 2022; *So... do powerful radio AGN even exist at the*

EoR?; 2022 meeting of the SKA Pathfinders Radio Continuum Surveys (SPARCS), Inter-university Institute for Data Intensive Astronomy, South Africa

8. **I. S. Albuquerque**, N. Frusciante; 2022; *A designer approach to f(Q) gravity and cosmological implications*; A SHOT IN THE DARK: New Challenges in Cosmology 2022, Lorentz Center, Leiden, the Netherlands
9. **T. Barata**; 2022; *Space Weather activities in Portugal and the Iberian Space Science Summer School Report*; International Space Weather Initiative Steering Committee Annual Meeting, Vienna (online), Austria
10. **D. D. Barbosa**, **J. Afonso**, **I. Matute**, **R. Carvajal**, S. Amarantidis, **C. Pappalardo**, I. H. Whittam, I. Heywood; 2022; *A Complete Characterisation of Ultra Steep Spectrum Sources in the COSMOS Field*; VLASS conference, Socorro (hybrid), USA
11. **T. Barreiro**; 2022; *Testing F(Q) gravity with redshift space distortions*; 23rd International Conference of General Relativity and Gravitation, Beijing, China
12. **T. Barreiro**; 2022; *Status of Dark Energy & Dark Matter*; International Space University Space Studies Program, Oeiras, Portugal
13. **S. C. C. Barros**; 2022; *Exoplanets with PLATO and GAIA*; Transient sky with Gaia, Coimbra, Portugal
14. **S. C. C. Barros**; 2022; *Status of the WG5 Feature characterise*; CHEOPS Science Team Meeting #24, Online, switzerland
15. **S. C. C. Barros**; 2022; *Status of the WG5 Feature characterise*; CHEOPS Science Team Meeting #25, Padova, Italy
16. **S. C. C. Barros**; 2022; *Status of the WG5 Feature characterise*; CHEOPS Science Team Meeting #26, Online, Switzerland
17. **S. C. C. Barros**; 2022; *Cheops reveals the tidal deformation of WASP-103b*; Cool Stars 21, Toulouse, France
18. **S. C. C. Barros**; 2022; *Cheops reveals the tidal deformation of WASP-103b*; CHEOPS Science Workshop VI, Online, Switzerland
19. **I. A. Costa**, **D. F. M. Folha**, **F. A. L. Pires**; 2022; *A astronomia como ciência portal para o ensino interdisciplinar: de uma práxis eficaz, ao desaparecimento curricular da astronomia;*; Porto International Conference on Research in Education 2022, Porto, Portugal
20. **I. A. Costa**, **D. F. M. Folha**, **F. A. L. Pires**; 2022; *Da formação contínua ao desenvolvimento profissional: de um imperativo laboral, a uma necessidade intrínseca – a estratégia co desenhada do Planetário do Porto – Centro Ciência Viva*; Congresso Internacional Escola, Identidades e Democracia, Porto, Portugal
21. **D. Bossini**; 2022; *IA and asteroseismology*; 9th Iberian Meeting on Asteroseismology, Montanejos, Spain
22. **J. Brinchmann**; 2022; *EUCLID and Gaia*; Transient Sky with Gaia, MW-Gaia WG2-WG4 workshop, Univ. Coimbra, Portugal
23. **S. L. L. Bourgeois**, A. Wagner, **T. Barata**, R. Erdelyi, O. Oliveira, R. Gafeira; 2022; *Identifying solar features with Mathematical Morphology*; 18th European Space Weather Week, Zagreb, Croatia
24. **F. Brasil**, **P. Machado**, **G. Gilli**, **A. Cardesín-Moinelo**, **J. Silva**, **D. C. Espadinha**, R Rianço-Silva, F. Rodrigues, B. Gondet; 2022; *Characterising Atmospheric Gravity Waves on Mars - a systematic study*; EGU General Assembly 2022, Vienna, Austria
25. **F. Brasil**, **P. Machado**, G. Gilli, A. Cardesín-Moinelo, **J. Silva**, **D. C. Espadinha**, R Rianço-Silva; 2022; *Probing Atmospheric Gravity Waves on Mars' Atmosphere Using Mars Express Omega Data*; 7th Mars Atmosphere Modelling and Observations Workshop, Paris, France
26. **F. Brasil**, **P. Machado**, G. Gilli, A. Cardesín-Moinelo, **J. Silva**, **D. C. Espadinha**, **R Rianço-Silva**; 2022; *Characterising Atmospheric Gravity Waves on Mars using Mars Express OMEGA images - novel results from systematised study*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
27. **F. Brasil**, **P. Machado**, G. Gilli, A. Cardesín-Moinelo, **J. Silva**, **D. C. Espadinha**, **R Rianço-Silva**; 2022; *Probing Atmospheric Gravity Waves on Mars' Atmosphere Using Mars Express Omega Data*; 7th Mars Atmosphere Modelling and Observations Workshop, Paris, France
28. **G. Fanizza**; 2022; *Hubble diagram and precision cosmology*; General Relativistic effects in observing the Large Scale Structure of the Universe, Porto, Portugal
29. **J. C. Fonseca**; 2022; *On the relevance of the relativistic effects in cross-correlations of future spectroscopic surveys*; General Relativistic effects in observing the Large Scale Structure of the Universe, Porto, Portugal
30. **N. M. Gonçalves**, **M. Abreu**, **D. Castro Alves**; 2022; *Comparison between the scanning pentaprism and the Hartman method for wavefront analysis*; 5th International Conference on Application of Optics and Photonics, Guimarães, Portugal
31. **J. Brinchmann**; 2022; *Update on MUSE-Faint*; Muse Busy Week, Potsdam, Germany
32. **J. Brinchmann**; 2022; *Update on Antlia B*; Muse Busy Week, Leiden, The Netherlands
33. L. E. Buchanan, M. E. Schwamb, W. Fraser, M. T. Bannister, M. Marsset, R. E. Pike, J. J. Kavelaars, S. D. Benecchi, M. J. Lehner, S. -Y. Wang, **N. Peixinho**, K. Volk, M. Alexandersen, Y. -T. Chen, B. Gladman, S. D. J. Gwyn, J.-M. Petit; 2022; *Exploring Variability within the Col-OSSOS Sample*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
34. **T. L. Campante**; 2022; *Galactic Archaeology and Asteroseismology: A Synergetic Approach*; Sub-Saharan Africa Advanced Astronomy Summer School, Entebbe, Uganda
35. **T. L. Campante**; 2022; *Homogeneous ages and masses for stars in the Ariel Reference Sample*; Ariel Consortium Meeting, Bologna, Italy
36. **T. L. Campante**; 2022; *Pushing the boundaries of cool-dwarf asteroseismology with ESPRESSO*; Asteroseismology in the Era of Surveys from Space and the Ground: Stars, Planets, and the Milky Way - TASC6/KASC13 Workshop, KU Luven, Belgium
37. A. Cardesín-Moinelo, C. Wilson, **P. Machado**, **F. Brasil**, P. Martín, D. Titov, B. Gondet; 2022; *Mars Wind & Wave Mapping (MWWM) research project: preliminary results*; 44th COSPAR Scientific Assembly, Athens, Greece
38. A. Cardesín-Moinelo, C. Wilson, **P. Machado**, **F. Brasil**, P. Martín, D. Titov, B. Gondet; 2022; *Wave Mapping (MWWM) project: Martian atmosphere dynamics seen from Earth telescopes, Space Missions and 3D climate models*; XV Reunión Científica Sociedad Española de Astronomia (SEA), Tenerife, Spain
39. **R. Carvajal**, **I. Matute**, **J. Afonso**, **S. Amarantidis**, **D. D. Barbosa**, **P. A. C. Cunha**, **A. Humphrey**; 2022; *Prediction of high-redshift Radio Galaxy candidates with ensemble Machine*; XVII SOCHIAS Meeting, online, Chile
40. **R. Carvajal**, **I. Matute**, **J. Afonso**, **S. Amarantidis**, **D. D. Barbosa**; 2022; *High-redshift Radio Galaxies candidates prediction with ensemble Machine Learning*; SAZERAC SIPS: Learning the high-redshift Universe, , Online
41. **R. Carvajal**, **I. Matute**, **J. Afonso**, S. Amarantidis, **D. D. Barbosa**, **P. A. C. Cunha**, A. Humphrey; 2022;

Searching for High-z Radio Galaxy Detections with Ensemble Machine Learning; EMU (Evolutionary Map of the Universe) International Virtual Meeting, , Online

42. **R. Carvajal**, **I. Matute**, **J. Afonso**, R. P. Norris, K. J. Luken, P. Sanchez-Sáez, **P. A. C. Cunha**, A. Humphrey, H. Messias, S. Amarantidis, **D. D. Barbosa**; 2022; *Ensemble Machine Learning for Radio Galaxy detections*; 2022 meeting of the SKA Pathfinders Radio Continuum Surveys (SPARCS), Inter-university Institute for Data Intensive Astronomy, South Africa
43. **R. Carvajal**, **I. Matute**, **J. Afonso**, S. Amarantidis, **D. D. Barbosa**; 2022; *Radio Galaxy detection prediction with ensemble Machine Learning*; International Conference on Machine Learning for Astrophysics - ML4Astro, Catania, Italy
44. **R. Carvajal**, **I. Matute**, **J. Afonso**, S. Amarantidis, **D. D. Barbosa**; 2022; *Searching for Radio Galaxy detections with ensemble Machine Learning*; VLASS conference, Socorro (hybrid), USA
45. Y.-S. Castillo-Rosales, A. Pais, J. M. Fernandes, J. Ribeiro, **A. L. Morozova**, F. J. G. Pinheiro; 2022; *Relating 27-Day averages of solar, interplanetary magnetic field parameters and geomagnetic activity proxies in solar cycle 24*; Latin American Conference on Space Geophysics, São José dos Campos, Brazil
46. S. Chierichini, **T. Barata**, E. Camporeale, J. M. Fernandes, R. Foldes, G. Francisco, G. de Gasperis, L. Giovannelli, D. Del Moro, R. Mugatwala, G. Napoletano, J. Teunissen; 2022; *Monte Carlo Markov Chain inference of the Probabilistic Drag Based Model's parameters for Coronal Mass Ejection propagation*; 18th European Space Weather Week, Zagreb, Croatia
47. **M. T. Clara**, **M. S. Cunha**, **P. P. Avelino**, **T. L. Campante**, D. R. Reese, S. Deheuvels; 2022; *Towards a Comprehensive Characterization of Seismic Forward Modelling and Grid Interpolation*; Asteroseismology in the Era of Surveys from Space and the Ground: Stars, Planets, and the Milky Way - TASC6/KASC13 Workshop, KU Luven, Belgium
48. **M. J. Conceição**, A. Krone-Martins, **A. C. da Silva**; 2022; *Upscaling of Cosmological N-body Simulations*; Proceedings 2022 IEEE 18 th International Conference on e-Science, Salt Lake City, Utah, USA
49. **M. J. Conceição**, A. Krone-Martins, **A. C. da Silva**; 2022; *A Simple Approach to the Emulation and Resolution Enhancement of Cosmological Simulations*; A SHOT IN THE DARK: New Challenges in Cosmology 2022, Lorentz Center, Leiden, the Netherlands
50. **M. Cortês**; 2022; *Biocosmology: Birth of a New Science (Lighting Talk)*; Science Foo Camp, San Francisco, California, USA
51. **M. Cortês**; 2022; *Biocosmology: Birth of a New Science*; Cosmology from Home 2022, Online
52. **I. A. Costa**; 2022; *Knowledge of Primary Teachers About Key Concepts: the Fragile Foundation of Astronomy Education*; 4th Shaw-IAU Workshop on Astronomy for Education, , Online
53. **M. S. Cunha**; 2022; *The legacy of space-based asteroseismolgy*; Cool Stars 21, Toulouse, France
54. **M. S. Cunha**; 2022; *An asteroseismic view of the A-F pulsators: intriguing and challenging!*; Asteroseismology in the Era of Surveys from Space and the Ground: Stars, Planets, and the Milky Way - TASC6/KASC13 Workshop, KU Luven, Belgium
55. **V. da Fonseca**; 2022; *Constraining a simple parametrisation for varying alpha*; 16th Iberian Cosmology Meeting, Barcelona, Spain
56. M. De Pra, N. Pinilla-Alonso, A. C. Souza Feliciano, C. Schambeau, B. Harvison, J. Emery, D. P. Cruikshank, Y. J. Pendleton, B. Holler, J. Stansberry, V. Lorenzi, T. Muller, A. Guilbert-Lepoutre, **N. Peixinho**, M. T. Bannister, R. Brunetto; 2022; *Discovering the Surface Composition of TNOs (DiSCo-TNOs) with the James Webb Space Telescope*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
57. **M. Deal**; 2022; *CESTAM: Transport of chemical elements*; Atelier codes stellaires du PNPS, Observatoire de Paris, France
58. **M. Deal**; 2022; *Le Soleil est-il une étoile chimiquement particulière?*; Journées SF2A 2022, Besançon, France
59. **E. Delgado Mena**; 2022; *Exoplanet host stars and the star-planet connection*; Exoplanets IV, Las Vegas, USA
60. **E. Delgado Mena**; 2022; *ARIEL stellar characterization: Stellar abundances sub-WG*; Ariel Consortium Meeting, Paris - Online, France
61. **O. Demangeon**; 2022; *ESPRESSO scratches the surface of the small planet population*; Exoplanets IV, Las Vegas, USA
62. **J. A Dias**, **P. Machado**, **J. Ribeiro**, **C. T. Freire**; 2022; *Atmospheric evolution and the search for species of astrobiological interest in the Solar System – Case Studies using the Planetary Spectrum Generator*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
63. **J. D. F. Dias**; 2022; *Generalizing models with variations of the fine-structure constant driven by scalar fields: extended Bekenstein model coupled to the dark sector*; 33rd Rencontres de Blois: Exploring the Dark Universe, Château of Blois, France
64. **J. D. F. Dias**, **P. Machado**, **J. Ribeiro**, **C. T. Freire**; 2022; *From atmospheric evolution to the search of species of astrobiological interest in the Solar System – Case-Studies using the Planetary Spectrum Generator*; EGU General Assembly 2022, Vienna, Austria
65. **D. C. Espadinha**, **P. Machado**, J. Peralta, **J. Silva**, **F. Brasil**; 2022; *Venus Atmospheric Dynamics: Akatsuki UVI and TNG HARPS-N observations*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
66. A. J. G. Falorca, **M. S. Cunha**, P. P. Avelino, J. Amaral, J. Pessoa, **D. Bossini**; 2022; *Probing the interior of Subdwarf B stars through asymptotic fitting of glitch signatures*; Cool Stars 21, Toulouse, Toulouse
67. **G. Fanizza**; 2022; *Non-Gaussianities in the Hubble-Lemaitre diagram*; 23rd International Conference of General Relativity and Gravitation, Beijing, China
68. **G. Fanizza**; 2022; *Understanding the non-Gaussianities in the Hubble-Lemaitre diagram*; SM&FT 2022 - The XIX Workshop on Statistical Mechanics and nonpertubative Field Theory, Bari, Italy
69. **J. P. Faria**; 2022; *Stellar activity at the cm/s level with ESPRESSO*; GPRV workshop, All Souls College, Oxford, UK
70. **J. Ferreira**, **T. Barreiro**, **N. J. Nunes**, **J. P. Mimoso**; 2022; *Forecasting F(Q) cosmology with LCDM background using standard sirens*; 16th Iberian Cosmology Meeting, Barcelona, Spain
71. J. Filho, P. Gordo, **N. Peixinho**, **R. Gafeira**, R. Melioio, A. M. Silva; 2022; *Satellite Star Tracker Breadboard with Space Debris Detection Capability for LEO*; 12th EASN International Conference on "Innovation in Aviation & Space for opening New Horizons", Barcelona, Spain
72. **J. C. Fonseca**; 2022; *Fisher forecasts for the MeerKLASS survey*; HITS 2022 - Hi Intensity Mapping in Trieste, Institute for Fundamental Physics of the Universe (IFPU), Trieste, Italy
73. M. Foroutan, S. Vilanova, S. Heleno, A. Murray, L. Pinto, A. Sajedifar, A. J. Falcão, M. Torkamani, C. Canora, **P. Pina**, G. Vieira, J. Fonseca; 2022; *Surface-rupturing*

paleoearthquakes in a context of slow deforming continental interiors: the Lower Tagus Valley fault, Central Portugal; EGU General Assembly 2022, Vienna, Austria

74. **C. T. Freire**, T. Widemann, T. Encrenaz, **P. Machado**, **J. A Dias**; 2022; *Observations of the (1-0) band of CO in Venus using VIRTIS-H aboard Venus Express*; EGU General Assembly 2022, Vienna, Austria
75. **N. M. Gonçalves**, **A. Cabral**, **M. Abreu**; 2022; *Trade-off analysis between cost and instrument size for cross disperserd echelle spectographs*; NYRIA Workshop 2022, Sarcedo, Italy
76. **T. B. Gonçalves**, **J. L. Rosa**, **F. S. N. Lobo**; 2022; *Sudden singularities in f(R,T) gravity*; 16th Iberian Cosmology Meeting, Barcelona, Spain
77. **T. B. Gonçalves**, **J. L. Rosa**, **F. S. N. Lobo**; 2022; *Sudden singularities in f(R,T) gravity*; 23rd International Conference of General Relativity and Gravitation, Beijing, China
78. **R. Lima**; 2022; *etting limits to light pollution: a change (in strategy) is going to come*; ROLAN 2022 - Responsible Outdoor Lighting At Night 2022, , Online
79. **P. Machado**; 2022; *MWWM research*; MEX Science Working Team Meeting #50, Laboratoire d'Astrophysique Marseille, France
80. **P. Machado**; 2022; *Mars Wind Wave Mapping project*; HRSC Team Meating, DLR- Berlin, Germany
81. **P. Machado**; 2022; *How some planets lost their habitability*; Global Conference On Environmental Science and Applications, Online, USA
82. **P. Machado**, **F. Brasil**, A. Cardesín-Moinelo, G. Gilli, **J. Silva**, **J. A Dias**, **J. Rodrigues**, **R Rianço-Silva**, **D. C. Espadinha**, **V. Silva**, B. Gondet; 2022; *MWWM - Mars Winds Waves and Modelling*; Mars Express Science Working Team Meeting and Science Workshop, Marseille, France
83. **P. Machado**; 2022; *First attempt to retrieve a Mars atmospheric wind map from Earth, using VLT/UVES during the 2018 global dust storm*; 7th Mars Atmosphere Modelling and Observations Workshop, Paris, France
84. **P. Machado**, **M. Silva**, A. Sánchez-Lavega, **J. Silva**, **D. C. Espadinha**, **F. Brasil**, **J. Ribeiro**; 2022; *Saturn atmosphere's winds with VLT/UVES Doppler velocimetry*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
85. **H. Miranda**, **C. Pappalardo**, **P. Papaderos**, **J. Afonso**, **I. Matute**, **C. Lobo**, **A. Paulino-Afonso**, **R. Carvajal**, **S. Lorenzoni**, **D. M. Santos**; 2022; *The FADO of SDSS galaxies*; PoSTER 2022, Virtual, USA
86. **N. A. M. Moedas**; 2022; *Exploring the effect of turbulent mixing in F-type stars*; 9th Iberian Meeting on Asteroseismology, Montanejos, Spain
87. **N. A. M. Moedas**, **D. Bossini**, **M. Deal**, B. Campilho; 2022; *Atomic Diffusion and Turbulent Mixing in Solar-Like Stars: Impact on the Fundamental Properties of FG-Type Stars*; Cool Stars 21, Toulouse, France
88. **N. A. M. Moedas**; 2022; *Chemical Transport Mechanisms in Solar-Like Stars: Exploring the Turbulent Mixing in FG-Type Stars*; Asteroseismology in the Era of Surveys from Space and the Ground: Stars, Planets, and the Milky Way - TASC6/KASC13 Workshop, KU Luven, Belgium
89. **E. M. P. S. Moreira**, **I. A. Costa**; 2022; *CoAstro: @an Astronomy Condo-a new possible path for GAIA's dissemination strategy*; MW-Gaia WG5 workshop. Breaking Barriers: Inspiring the Next Generation, Santiago de Compostela, Spain
90. **A. L. Morozova**, **T. Barata**, **T. Barlyaeva**; 2022; *Performance of PCA-NN and PCA-MRM models for TEC over the Iberian Peninsula*; 15th Quadrennial Solar Terrestrial Physics Symposium, Alibag (online), India
91. **A. L. Morozova**, **T. Barata**, **T. Barlyaeva**; 2022; *Comparison of the performance of PCA-NN models for daily mean TEC over the Iberian Peninsula: performance of different neural networks configuration*; 2nd Machine Learning in Heliophysics, Boulder (hybrid), USA
92. **A. L. Morozova**, **T. Barata**, **T. Barlyaeva**; 2022; *Comparison of the performance of PCA-NN models for TEC over the Iberian Peninsula: the role of space weather parameters as predictors for TEC*; EGU General Assembly 2022, Vienna, Austria
93. **A. L. Morozova**, **R. Gafeira**, **T. Barata**, **T. Barlyaeva**; 2022; *A prototype for a PCA-NN model for TEC with space weather parameters as predictors: selection of a NN algorithm and a set of predictors*; 18th European Space Weather Week, Zagreb, Croatia
94. **A. L. Morozova**, **T. Barata**, **I. Oliveira**, **J. P. M. F. Pereira**; 2022; *Ionospheric parameters over Portugal during quiet and disturbed periods*; 10th Spanish-Portuguese Assembly of Geodesy and Geophysics, Toledo, Spain
95. **A. L. Morozova**, **T. Barata**, **T. Barlyaeva**, **R. Gafeira**; 2022; *Comparison of different approaches to a PCA-NN model for TEC with space weather parameters as predictors*; AGU Fall meeting 2022, Chicago (hybrid), USA
96. **A. L. Morozova**, **R. Gafeira**, **T. Barata**, **T. Barlyaeva**; 2022; *Development of a prototype for a PCA-NN model for TEC with space weather parameters as predictors*; The 5th ISEE Symposium: Toward the Future of Space–Earth Environmental Research, Nagoya University (hybrid), Japan
97. **N. J. Nunes**; 2022; *Cosmological constraints on a simple model for varying alpha*; 23rd International Conference of General Relativity and Gravitation, Beijing, China
98. **C. Pappalardo**; 2022; *Stellar age and metallicity of galaxies in spectral synthesis methods*; Large-Volume Spectroscopic Analyses of AGN and Star Forming Galaxies in the Era of JWST, STScI, Baltimore (online), USA
99. **C. Pappalardo**; 2022; *The promise of Radio Astronomy. New paths for Astrophysics in Africa*; 2022 European Astronomical Society Annual Meeting, Valencia, Spain
100. **C. Pappalardo**; 2022; *Mean stellar metallicity of galaxies in spectral synthesis methods: a quantitative test using different approaches*; Charting the metallicity evolution history of the Universe, Catania, Italy
101. **C. Pappalardo**; 2022; *The dust-stars interplay in late-type galaxies at $z < 0.5$*; 2022 European Astronomical Society Annual Meeting, Valencia, Spain
102. **C. Pappalardo**; 2022; *The star formation history of galaxies in spectral synthesis methods*; 2022 European Astronomical Society Annual Meeting, Valencia, Spain
103. J. Peralta, A. Galeote, Y. J. Lee, M. A. Bullock, E. F. Young, **P. Machado**, **D. C. Espadinha**, R. Baena; 2022; *The circulation at the nightside lower clouds of Venus with high-precision winds*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
104. **C. P. Pereira**; 2022; *Stabilization of calibration light sources for High Accuracy Photometry Instruments in Astronomy*; NYRIA Workshop 2022, Sarcedo, Italy
105. R. E. Pike, **N. Peixinho**; 2022; *Col-OSSOS: The Distribution of Surface Classes in Neptune's Resonances*; 54th Annual Meeting of the Division for Planetary Sciences, Ontario (and online), Canada

106. **J. Retrê**; 2022; *How to give a talk*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
107. **J. Ribeiro**, **P. Machado**, S. Pérez-Hoyos; 2022; *Preliminary atmospheric study of Jupiter using ISO/SWS data*; NEMESIS workshop, Oxford, UK
108. **J. Ribeiro**, **P. Machado**, S. Pérez-Hoyos, **J. A Dias**; 2022; *Preliminary atmospheric study of Jupiter using ISO/SWS data*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
109. **J. Ribeiro**, **P. Machado**, **S. Pérez-Hoyos**, **J. A Dias**; 2022; *A reanalysis of ISO-SWS Jupiter observations: preliminary results*; EGU General Assembly 2022, Vienna, Austria
110. **P. M. Sá**; 2022; *Coupled quintessence with a generalized interaction term*; 23rd International Conference of General Relativity and Gravitation, Beijing, China
111. **A. R. G. Santos**, S. Mathur, R. García; 2022; *The impact of metallicity on the evolution of rotation and magnetism of solar-like stars*; 9th Iberian Meeting on Asteroseismology, Montanejos, Spain
112. **A. R. G. Santos**, S. N. Breton, S. Mathur, R. García; 2022; *Surface Rotation And Photometric Magnetic Activity For 55,000+ Solar-Like Stars Observed By Kepler*; Cool Stars 21, Toulouse, France
113. **A. R. G. Santos**, S. Mathur, R. García, Z. R. Claytor, A.-M. Broomhall, J. L. Van Saders, R. Egeland; 2022; *Magnetic activity in the Sun and solar-like stars*; Cool Stars 21, Toulouse, France
114. **D. M. Santos**, **C. Pappalardo**; 2022; *Characterising galaxies with FADO*; PoSTER 2022, Virtual, USA
115. **N. C. Santos**; 2022; *Stellar astrophysics and exoplanets: lessons and challenges*; MWGaia workshop on Fundamental Stellar parameters from asteroseismology in the era of Gaia, Aarhus, Denmark
116. **N. C. Santos**; 2022; *Top Level Requirements for Astronomical Instrumentation*; Sub-Saharan Africa Advanced Astronomy Summer School, Entebbe, Uganda
117. **N. C. Santos**; 2022; *The star-planet connection*; Sub-Saharan Africa Advanced Astronomy Summer School, Entebbe, Uganda
118. **N. C. Santos**; 2022; *Exoplanet detection methods*; Sub-Saharan Africa Advanced Astronomy Summer School, Entebbe, Uganda
119. **N. C. Santos**; 2022; *Looking for other Earths*; XLV reunião anual da Sociedade Astronómica Brasileira, Online, Brazil
120. **A. M. Silva**; 2022; *s-BART: a semi-Bayesian implementation of template matching for precise Radial Velocities*; Exoplanets IV, Las Vegas, USA
121. **J. Silva**, **P. Machado**, **F. Brasil**, **R. Gonçalves**, **M. Silva**; 2022; *Jupiter's banded circulation through the eyes of VLT/ESPRESSO*; Europlanet Science Congress (EPSC) 2022, Granada, Spain
122. **B. Soares**, **V. Zh. Adibekyan**, C. Dorn, **S. G. Sousa**, **N. C. Santos**, B. Bitsch, G. Israelian, C. Mordasini, M. Oshagh, M. Kunimoto, Y. Takeda, E. Jofré, R. Petrucci, E. Martioli; 2022; *A compositional link between rocky exoplanets and their host stars*; MW-Gaia WG5 workshop. Breaking Barriers: Inspiring the Next Generation, Santiago de Compostela, Spain
123. **L. Sousa**; 2022; *Emission of gravitational waves by superconducting cosmic strings*; Gravitational Wave Probes of Physics Beyond Standard Model 2, University of Warsaw (online), Poland
124. **S. G. Sousa**; 2022; *CHEOPS TS3 report*; CHEOPS Science Team Meeting #24, Online, Switzerland
125. **S. G. Sousa**, M. Carena; 2022; *CHEOPS TS3 report*; CHEOPS Science Team Meeting #25, Padova, Italy
126. **I. Tereno**; 2022; *The building of the Euclid Surveys*; Advanced Euclid School, Les Houches, France
127. **I. Tereno**; 2022; *Euclid Surveys*; Euclid:UK Meeting 2022, Royal Astronomical Society (online), UK
128. **I. Tereno**; 2022; *The 1919 eclipse measurements in a nutshell*; 4th International Conference on the History of Physics, Trinity College Dublin, Ireland
129. C.-B. Varela, **R. Lima**, S. Bará; 2022; *The municipality that faded-out from VIIRS-DNB images*; Light Pollution: Theory, Modelling and Measurements 2022, Santiago de Compostela, Galicia, Spain
130. **D. A. D. Vaz**, **J. Brinchmann**; 2022; *Leo T Ultra-Faint Dwarf*; 23rd MUSE Science Busy Week, Potsdam, Germany
131. **D. A. D. Vaz**, **J. Brinchmann**; 2022; *Leo T dissected with MUSE-Faint*; 24th MUSE Science Busy Week, Leiden, The Netherlands
132. **B. Wehbe**; 2022; *The ESO-ELT-ANDES Front End*; NYRIA Workshop 2022, Sarcedo, Italy
133. G. Goyanes, V. Miranda, **P. Pina**, S. Heleno; 2022; *Comparative analysis between two different methodologies to characterize the vegetation cover in Byers Peninsula*; XIV Portuguese Conference on Polar Sciences, CCMAR/UAlg, Faro, Portugal
134. **I. M. Leite**, **A. Cabral**, **M. Abreu**, **N. C. Santos**; 2022; *Imaging sensors for PoET: a spatially resolved solar spectroscopy instrument*; 5th International Conference on Application of Optics and Photonics, Guimarães, Portugal
135. **P. Machado**; 2022; *Planetary Atmospheres: From Solar System to Exoplanets*; International Space University Space Studies Program, Oeiras, Portugal
136. **I. Matute**; 2022; *Machine Learning in Astrophysics*; Machine Learning in Science, Lisboa (online), Portugal
137. **A. W. Neitzel**, **D. Bossini**, **T. L. Campante**, **N. A. M. Moedas**; 2022; *Stellar Characterization for the Ariel Space Mission*; FÍSICA 2022 – 23ª Conferência Nacional de Física e 32º Encontro Ibérico para o Ensino da Física, Porto, Portugal
138. **C. P. Pereira**; 2022; *Characterization of Light Diffraction by a Digital Micromirror Device (DMD)*; 5th International Conference on Application of Optics and Photonics, Guimarães, Portugal
139. **S. Pereira**; 2022; *Storytelling Day*; International Space University Space Studies Program, Oeiras, Portugal
140. **N. C. Santos**; 2022; *Our Solar System and Exoplanets*; Space Studies Program 2022, International Space University, Oeiras, Portugal
141. G. Vieira, G. Prates, G. Goyanes, M. Angel de Pablo, M. Farzamian, M. Oliva, A. Correia, A. P. Valadares, J. Baptista, C. Mora, **P. Pina**; 2022; *New observations on the kynematics of Hurd rockglacier (Livingston Island, Antarctic Peninsula)*; 10th International Conference on Geomorphology, Coimbra, Portugal

National Scientific Communications [61]

1. **I. S. Albuquerque**; 2022; *designer approach to f(Q) gravity and cosmological implications*; Encontro com a Ciência e Tecnologia em Portugal 2022, Encontro com a Ciência e Tecnologia em Portugal 2022, Portugal
2. **I. S. Albuquerque**; 2022; *Cosmological Signatures of Modified Gravity: from theory to observations*; Jornadas Doutorais do Departamento De Física, Lisboa, Portugal

3. **I. S. Albuquerque**; 2022; *A designer approach to f(Q) gravity and cosmological implications*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
4. **D. D. Barbosa**, **J. Afonso**, **I. Matute**, **R. Carvajal**, S. Amarantidis, **C. Pappalardo**, I. H. Whittam, I. Heywood; 2022; *A Complete Characterisation of Ultra Steep Spectrum Sources in the COSMOS Field*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
5. **D. D. Barbosa**; 2022; *Objective Criteria for the Selection of the Most Distant Radio Galaxies*; Jornadas Doutorais do Departamento De Física, Lisboa, Portugal
6. **D. D. Barbosa**; 2022; *Objective Criteria for the Selection of the Most Distant Radio Galaxies*; Encontro com a Ciência e Tecnologia em Portugal 2022, Lisboa, Portugal
7. **T. Barreiro**; 2022; *Testing F(Q) gravity with redshift space distortions*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
8. **F. Brasil**, **P. Machado**, G. Gilli, **A. Cardesín-Moinelo**, **J. Silva**, **D. C. Espadinha**, **R Rianço-Silva**; 2022; *Atmospheric Gravity Waves on Mars using OMEGA/Mars Express images - novel results from systematised study*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
9. **F. Brasil**, **P. Machado**, G. Gilli, A. Cardesín-Moinelo, **J. Silva**, **D. C. Espadinha**, **R Rianço-Silva**; 2022; *Probing Atmospheric Gravity Waves on Mars' Atmosphere Using Mars Express Omega Data*; Ciências Research Day, Lisboa, Portugal
10. **R. Carvajal**, **J. Afonso**, **I. Matute**, **S. Amarantidis**, **D. D. Barbosa**; 2022; *Prediction of distant Radio Galaxies candidates with Machine Learning*; Jornadas Doutorais do Departamento De Física, Lisboa, Portugal
11. **R. Carvajal**, **I. Matute**, **J. Afonso**, S. Amarantidis, **D. D. Barbosa**; 2022; *Ensemble Machine Learning for the Extraction of High-Redshift Radio Galaxies*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
12. **R. Carvajal**, **J. Afonso**, **I. Matute**, S. Amarantidis, **D. D. Barbosa**; 2022; *Finding high-redshift Radio Galaxies with Machine Learning*; Encontro com a Ciência e Tecnologia em Portugal 2022, Lisboa, Portugal
13. **A. S. C. Carvalho**; 2022; *Galaxy Cluster Counts with Euclid*; Jornadas Doutorais do Departamento De Física, Lisboa, Portugal
14. **A. S. C. Carvalho**; 2022; *Euclid Cluster Abundances as a probe of Non-homogeneous models and the Cosmological Principle*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
15. **D. M. L. Castelão**; 2022; *Testing Unified Dark Matter-Energy models in the nonlinear regime*; 7th IDPASC/LIP Students Workshop, Universidade de Coimbra, Portugal
16. **P. A. C. Cunha**, A. Humphrey; 2022; *Photometric redshift-aided classification using ensemble learning*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
17. **T. de Azevedo Silva**; 2022; *Detection of Barium in the atmospheres of ultra-hot gas giants*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
18. **J. A Dias**, **P. Machado**, **J. Ribeiro**, **C. T. Freire**; 2022; *Atmospheric evolution and the search for species of astrobiological interest in the Solar System*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
19. **J. D. F. Dias**; 2022; *Generalizing models with variations of the fine-structure constant driven by scalar fields: extended Bekenstein*; 7th IDPASC/LIP Students Workshop, Universidade de Coimbra, Portugal
20. **J. D. F. Dias**; 2022; *Constraints on extended Bekenstein models from cosmological, astrophysical and local data*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
21. **D. C. Espadinha**, **P. Machado**, J. Peralta, **J. Silva**, **F. Brasil**; 2022; *Venus Atmospheric Dynamics: Akatsuki UVI and TNG HARPS-N observations*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
22. **C. T. Freire**, T. Widemann, T. Encrenaz, **P. Machado**, **J. A Dias**; 2022; *Observations of the (1-0) band of CO in Venus using VIRTIS-H aboard Venus Express*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
23. **N. M. Gonçalves**, **A. Cabral**, **M. Abreu**; 2022; *Parametric design of a cross dispersed echelle spectograph with off the shelf components*; FÍSICA 2022 – 23ª Conferência Nacional de Física e 32º Encontro Ibérico para o Ensino da Física, Porto, Portugal
24. **N. M. Gonçalves**, **A. Cabral**, **M. Abreu**; 2022; *UV spectroscopy with a small cross dispersed echelle spectrograph for space applications*; Jornadas Doutorais do Departamento De Física, Lisboa, Portugal
25. **N. M. Gonçalves**, **A. Cabral**, **M. Abreu**; 2022; *UV spectroscopy with a small cross dispersed echelle spectrograph for space applications*; Encontro com a Ciência e Tecnologia em Portugal 2022, Lisboa, Portugal
26. **N. M. Gonçalves**, **A. Cabral**, **M. Abreu**; 2022; *UV spectroscopy with a small cross dispersed echelle spectrograph for space applications*; Ciências Research Day, Lisboa, Portugal
27. **N. M. Gonçalves**, **A. Cabral**, **M. Abreu**; 2022; *Optical design for a prototype of a cross dispersed echelle spectrograph*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
28. **T. B. Gonçalves**, **J. L. Rosa**, **F. S. N. Lobo**; 2022; *Tweaking Gravity*; 7th IDPASC/LIP Students Workshop, Universidade de Coimbra, Portugal
29. **T. B. Gonçalves**, **J. L. Rosa**, **F. S. N. Lobo**; 2022; *Cosmology in scalar-tensor f(R,T) gravity*; Jornadas Doutorais do Departamento De Física, Lisboa, Portugal
30. **T. B. Gonçalves**, **J. L. Rosa**, **F. S. N. Lobo**; 2022; *Cosmology in scalar-tensor f(R,T) gravity*; Encontro com a Ciência e Tecnologia em Portugal 2022, Lisboa, Portugal
31. **I. M. Leite**, **A. Cabral**, **M. Abreu**, **N. C. Santos**; 2022; *Instrumentation for spacially resolved solar spectroscopy*; Encontro com a Ciência e Tecnologia em Portugal 2022, Lisboa, Portugal
32. **P. Machado**, **M. Silva**, A. Sánchez-Lavega, **J. Silva**, **D. C. Espadinha**, **F. Brasil**, **J. Ribeiro**; 2022; *Saturn atmosphere's winds with VLT/UVES Doppler velocimetry*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
33. **C. J. A. P. Martins**; 2022; *An overview of ELT Line Calibrations WG activities*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
34. **J. P. Mimoso**; 2022; *Generalising Conformal Time*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
35. **H. Miranda**, **C. Pappalardo**, **P. Papaderos**, **J. Afonso**, **I. Matute**, **C. Lobo**, **A. Paulino-Afonso**, **R. Carvajal**, **S. Lorenzoni**, **D. M. Santos**; 2022; *An investigation of the star-forming main sequence considering the nebular continuum emission at low-z*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
36. V. Miranda, **P. Pina**, S. Heleno, G. Vieira, H. Lee, S. Hong; 2022; *Vegetation classification using synergistic remote sensing and machine learning in Barton*

Peninsula, King George Island, Antarctica; XIV Portuguese Conference on Polar Sciences, CCMAR/UAlg, Faro, Portugal

37. **N. A. M. Moedas**; 2022; *The chemical transport mechanisms in stellar interiors: atomic diffusion and macroscopic transport process*; Encontro com a Ciência e Tecnologia em Portugal 2022, Lisboa, Portugal
38. C. Mora, G. Vieira, **P. Pina**, D. Whalen, A. Bartsch; 2022; *High resolution detection of intra-seasonal dynamics of permafrost coasts using TERRASAR-X imagery (Beaufort Sea, Canada)*; XIV Portuguese Conference on Polar Sciences, CCMAR/UAlg, Faro, Portugal
39. **A. L. Morozova**, **T. Barata**, **S. J. Carvalho**, **P. Lacerda**, **R. Lima**, **N. Peixinho**, **P. Pina**; 2022; *Space Studies at IA-UC*; Dia da Investigação do DF, Coimbra, Portugal
40. **A. W. Neitzel**, **D. Bossini**, **T. L. Campante**; 2022; *Homogenous Stellar Characterization for the Ariel Space Mission*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
41. J. Nunes, G. Vieira, M. Farzamian, C. Freitas, **P. Pina**; 2022; *New observations on the geomorphological evolution of the Nave de Santo António (Serra da Estrela, Portugal).*; 10th International Conference on Geomorphology, Coimbra, Portugal
42. **N. J. Nunes**; 2022; *Cosmological constraints on a simple model for varying alpha*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
43. **N. Peixinho**; 2022; *A Astronomia como Universo de Interdisciplinaridade no Ensino*; VIII Ciclo de Conferências da Faculdade de Ciências da Universidade da Beira Interior, UBI, Covilhã, Portugal
44. N. Peixinho; 2022; *O que é a matéria para um materialista quiçá místico?*; Jornadas de Filosofia & Física, UBI, Covilhã, Portugal
45. **C. P. Pereira**; 2022; *VIS/NIR Illumination System for the OGSE of ARIEL Space Mission*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
46. **C. P. Pereira**; 2022; *Stabilization of calibration light sources for High Accuracy Photometry Instruments*; Jornadas Doutorais do Departamento De Física, Lisboa, Portugal
47. **C. P. Pereira**; 2022; *Light source stabilization system for High Accuracy Photometry Instruments in Astronomy*; Encontro com a Ciência e Tecnologia em Portugal 2022, Lisboa, Portugal
48. **J. Retrê**; 2022; *Viver Astronomia no IA*; Conferência Espacial, Santa Maria, Açores, Portugal
49. **J. Ribeiro**, **P. Machado**, S. Pérez-Hoyos; 2022; *A reanalysis of ISO-SWS Jupiter observations using NEMESIS: first results*; Ciências Research Day, Lisboa, Portugal
50. **J. Ribeiro**, **P. Machado**, S. Pérez-Hoyos, **J. A Dias**; 2022; *Preliminary atmospheric study of Jupiter using ISO/SWS data*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
51. **F. Rodrigues**, **E. Reis**, **P. Machado**, **F. Brasil**, **D. C. Espadinha**; 2022; *Identification and Characterization of Morphological evidence associated with Fluvio marine Environments on Mars*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
52. **A. R. G. Santos**; 2022; *Variability in the magnetic activity of Kepler solar-like stars*; Stars Day 2022, Porto, Portugal
53. **A. R. G. Santos**; 2022; *Magnetic activity in the Sun and solar-like stars*; SAM workshop #1, Porto, Portugal
54. **N. C. Santos**; 2022; *PoET: a solar telescope for planet hunters*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
55. **N. C. Santos**; 2022; *The PoET solar telescope*; SAM workshop #1, Porto, Portugal
56. **N. C. Santos**; 2022; *Planetary Systems@IA*; IA-ON9 meeting, Online, Portugal
57. **A. M. Silva**; 2022; *Spectral modelling with GPs: first steps towards a fully Bayesian RV model*; SAM workshop #1, Porto, Portugal
58. **J. Silva**, **P. Machado**, **F. Brasil**, **R. Gonçalves**, **M. Silva**; 2022; *Jupiter's atmosphere dynamics with Doppler Velocimetry*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
59. **B. Soares**, **V. Zh. Adibekyan**, **N. C. Santos**, **E. Delgado Mena**, **S. G. Sousa**; 2022; *From stellar to planetary compositions: the challenging case of M dwarfs*; IJUP'22 – 15º Encontro de Investigação Jovem da Universidade do Porto, Porto, Portugal
60. **S. R. P. Veiga**, **A. H. M. Cabral**, **C. J. A. P. Martins**; 2022; *Statistical analysis of different dark energy and modified gravity type models*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal
61. **B. Wehbe**; 2022; *The Atmospheric Dispersion Compensator of NIRPS, the Near InfraRed Planet Searcher,*; XXXII Encontro Nacional de Astronomia e Astrofísica, Lisboa, Portugal

Seminars at IA [29]

1. *Exoplanet system architecture: Planets on peculiar orbits*
2. Barkhudaryan, L. V.; 2022; *Constraining Type Ia supernovae through their heights in edge-on galaxies*
3. Barragán, O.; 2022; *Detection of planetary signals in cases of extreme stellar activity*
4. Chamba, C.; 2022; *A historical perspective on the concept of galaxy size*
5. Conzinu, P.; 2022; *Adiabatic renormalization with an IR cut-off*
6. Corasaniti, P. S.; 2022; *Probing Cosmology with Galaxy Cluster Sparsity*
7. Cotsakis, S.; 2022; *Dynamical synchronization and the horizon problem*
8. Dirian, Y.; 2022; *Theory and observational constraints in nonlocal gravity*
9. Farrah, D.; 2022; *The cosmic evolution of active galaxies, and the assembly of their black holes*
10. Frank, A.; 2022; *The Photo-Evaporation of Exoplanet Atmospheres: What We Learn From 3-D Simulations*
11. Kaltenegger, L.; 2022; *Searching for another Earth*
12. Koksbang, S. M.; 2022; *Redshift drift in inhomogeneous universe models with concrete abstract cosmology*
13. Llinares, C.; 2022; *My journey with MOND*
14. Machado, P.; 2022; *Planetary atmospheres - A roadmap of planets that lost their habitability*
15. Magg, E.; 2022; *Our Sun's chemical makeup: a fresh look at the old question*
16. Messias, H.; 2022; *The Atacama Compact Array as a survey machine of the early Universe*
17. Minazzoli, O.; 2022; *Entangled relativity*
18. Murphy, M. T.; 2022; *Fundamental physics with solar twins*

19. Nielsen, M. B.; 2022; *Detecting solar-like oscillators with TESS*
20. Nurmi, S.; 2022; *Looking beyond the inflaton sector: why should we be interested in spectators?*
21. Robert, S.; 2022; *Shall we detect volcanism on Venus?*
22. Sá, P. M.; 2022; *Unification of Inflation, Dark Matter, and Dark Energy with Scalar Fields*
23. Saadeh, D.; 2022; *Dark energy: can we Vainshtein screen a fifth fundamental force?*
24. Schiavone, T.; 2022; *Running Hubble constant from the SNe Ia Pantheon sample and BAOs?*
25. Shafieloo, A.; 2022; *Status of the Concordance Model of Cosmology*
26. Sobral, D.; 2022; *Resolving the formation and evolution of primeval galaxies: from re-ionisation to cosmic noon*
27. Sozzetti, A.; 2022; *Gaia and exoplanets: DR2, (E)DR3, and beyond*
28. Terças, H.; 2022; *Towards the detection of ultra-low energetic neutrinos with plasma metamaterials*
29. Umeh, O.; 2022; *The art of building a smooth cosmic distance ladder in a perturbed universe*

Organization of Conferences [6]

1. *SAM workshop #1*; 13 May 2022; Porto, Portugal
2. *Stars Day 1.5*; 20 May 2022; Observatório Geofísico e Astronómico da Universidade de Coimbra, Portugal
3. *General Relativistic effects in observing the Large Scale Structure of the Universe*; 20 to 23 June 2022; Porto, Portugal
4. *IA-ON9; Instituto de Astrofísica e Ciências do Espaço 9th internal workshop*; 11 November 2022; Portugal
5. *Stars Day 2022*; 16 December 2022; Porto, Portugal
6. *COSMONATA 2022*; 22 December 2022; Online, Portugal

Observing runs [17]

1. C. Danielski et al. (including, T. L. Campante, M. Tsantaki, E. Delgado Mena), Building a public catalogue of homogeneously characterised Ariel exoplanet-host stars, Program ID: 109.23J9, Ultraviolet and Visual Echelle Spectrograph (UVES) at the Very Large Telescope (VLT), Period 109
2. C. Manara et al. (including, J. F. Gameiro); *PENELLOPE: the ESO data legacy program to complete the Hubble UV Legacy Library of Young Stars (ULLYSES)*; 1106.C-1047, VLT (ESO)/ESPRESSO+XSHOOTER+UVES, 255.7hours, October 2020 - September 2022
3. D. Armstrong et al. (including, E. Delgado Mena); “Uncovering the origin of remnant planets in the hot Neptunian Desert”; 108.21YY (other observers); HARPS/ESO-La Silla 3.6m., P108-P109 remote observing
4. E. Delgado Mena et al.; “RV variations in evolved stars in open clusters: planets, oscillations or stellar activity?”; 108.22LE (other observers); HARPS/ESO-La Silla 3.6m; period 108 remote observing
5. G. Alecian, C. Dougados et al. (including, J. F. Gameiro); *Magnetic-snapshot survey of Class I and Flat Spectrum protostars*; CFHT/SPIRou; K1-01-00039, 36 hours, semester 22B, November 2022 – January 2023
6. H. Uitenbroek, C. Quintero, R. Gafeira, B. Cobo; The Structure of smallscale Magnetic Elements from Photosphere to Chromosphere; DKIST; VISP; March 2022
7. J. Gomes da Silva, N. Santos, P. Figueira, M. Oshagh, J. P. Faria, S. Barros, O. Demangeon, V. Adibekyan, S. Sousa, E. Delgado Mena, J. Martins; Follow-up observations of G 9-40b with ESPRESSO: A temperate super-Earth or sub-Neptune?; 108.22BT, ESPRESSO @ VLT; P108
8. J. P. Faria, HARPS programs, HARPS, ESO 3.6m, 15-19 April 2022
9. J.-F. Donati et al. (including J. F. Gameiro); *SPICE: Consolidating & Enhancing the SPIRou Legacy Survey*; CFHT/SPIRou, 174.28 nights, 4 semesters 2022b - 2024a.
10. J. Peralta, P.Machado et al., IRTF SPEX and MIRSI, MaunKea Observatory, Hawaii, USA, February 2022
11. MUSE GTO team (including, J. Brinchmann); MUSE GTO run 48; MUSE/VLT; 22-28 Oct 2022
12. P. Jáchym et al. (including, T. Scott), C8 large program, ALMA JELLY, ALMA, ongoing
13. R. Carvajal et al., Pooled observations (different projects and configurations), NIKA2 and EMIR, 30m Pico Veleta Radio Telescope, IRAM, Spain, 15-21 November 2022
14. S. A. G. Sousa; A. Mortier; N. C. Santos; B. Rojas Ayala; V. Adibekyan; G. Israelian; O. Demangeon; S. C. C. Barros; A. Antoniadis Karnavas; E. Delgado Mena; M. Tsantaki; B. Soares, Know the star to know the planet: improving SWEET-CAT with homogeneous planet-host parameters; 109.22VY; UVES/VLT; period 109 service mode
15. S. Amarantidis, I. Matute , J. Afonso, Jess Broderick, Nick Seymour; Breaking the wall: Identifying powerful radio galaxies at the Epoch of Reionisation; 089-22; EMIR and NIKA2 instruments at the IRAM-30M telescope; Onsite 14-23 November 2022
16. T. L. Campante et al. (including, N. C. Santos, V. Adibekyan, M. S. Cunha), Pushing the boundaries of cool-dwarf asteroseismology with ESPRESSO, Program ID: 109.236P, Echelle SPectrograph for Rocky Exoplanets and Stable Spectroscopic Observations (ESPRESSO) at the Very Large Telescope (VLT), Period 109
17. U. Jørgensen, et al. (including, N. Peixinho), MiNDSTEp (Microlensing Network for the Detection of Small Terrestrial Exoplanets), DFOSC / Lucky Imaging - 1.5m Danish Telescope, ESO-La Silla, 13-27 June 2022

Outreach talks [246]

1. A. Cabral, "Telescópio Espacial James Webb: Uma revolução?", Mesa redonda organizada pelo Instituto de Astrofisica e Ciências do Espaço [online], 29 January
2. A. Cabral, "Grandes telescópios, espectrógrafos e a luz em busca de planetas extra solares", Escola Secundaria Alves Martins - Viseu [online], 22 April
3. A. Cabral, "Astronomia XXL", 7ª Concentração de Telescópios em Moimenta da Beira, 28 May
4. A. Cabral, "A Magia da Luz e da cor", Escola Básica e Secundária Padre Alberto Neto Queluz, 2 May
5. A. Cabral, "MOONS live from Chile: the next multi-object spectrograph for ESO's Paranal Observatory", FCUL Research Day, 26 October
6. A. R. Costa Silva, Uma Aventura no Atacama, Planetário do Porto, 5 October 2022
7. A. R. Costa Silva, Como detetar planetas longínquos?, Online, 23 November 2022

8. A. W. Neitzel, Determinação da idade e da massa de estrelas sísmicas no catálogo Ariel, Universidade do Porto, 27 April 2022
9. A. R. G. Santos, Testimony in the context of the International Day of Women and Girls in Science, Escola Secundária Dr Jaime de Magalhães Lima - Aveiro - Portugal, 8 March
10. A. R. G. Santos, Stellar Magnetic Activity, 4th Summer School of Astronomy - IST - Lisbon - Portugal, 8 September
11. C. Lobo, A evolução atribulada das galáxias, Faculdade de Ciências da Universidade do Porto (Etapa regional das Olimpíadas de Física), 23 April
12. C. Lobo, A Via Láctea e as outras galáxias, online talk for Escola Secundária de São Pedro do Sul (in the framework of ESERO - O Espaço vai à Escola), 12 October
13. C. Lobo, A Via Láctea e as outras galáxias, online talk for Clube Ciência Viva da Escola Básica de Santo Onofre, Caldas da Rainha (in the framework of ESERO - O Espaço vai à Escola), 12 October
14. C. Lobo, A Via Láctea e as outras galáxias, Escola Secundária Dr. José Macedo Fragateiro, Ovar (in the framework of ESERO - O Espaço vai à Escola), 19 October
15. C. Lobo, A Via Láctea e as outras galáxias, online talk for Escola Básica Guilherme Stephens, Marinha Grande (in the framework of ESERO - O Espaço vai à Escola), 26 October
16. C. Lobo, A Via Láctea e as outras galáxias: uma viagem através do Universo, Escola Básica Maria Lamas, Porto, 3 November
17. C. Lobo, A Via Láctea e as outras galáxias: uma viagem através do Universo, Escola Básica e Secundária de Fontes Pereira de Melo, Porto, 4 November
18. C. J. A. P. Martins, A Física da Relatividade, 9 May, ES Raul Proença, Caldas da Rainha
19. C. J. A. P. Martins, A Física da Atmosfera e do Aquecimento Global, 6 October, ES de Rio Tinto
20. C. J. A. P. Martins, A Física da Vida e dos Extraterrestres, 7 October, ES de Fornos de Algodres
21. C. J. A. P. Martins, A Física da Atmosfera e do Aquecimento Global, 11 October, ES de S. Roque do Pico
22. C. J. A. P. Martins, The Physics of the Atmosphere and Global Warming, 12 October, ES Camilo Castelo Branco, Famalicão
23. C. J. A. P. Martins, A Física da Relatividade, 12 October, ES Camilo Castelo Branco, Famalicão
24. C. J. A. P. Martins, A Física da Radioactividade e do Cancro, 12 October, ES D.Sancho I, Famalicão
25. C. J. A. P. Martins, A Física da Relatividade, 14 October, ES José Saramago, Mafra
26. C. J. A. P. Martins, A Física da Atmosfera e do Aquecimento Global, 17 October, ES de S. Pedro do Sul
27. C. J. A. P. Martins, A Física da Radioactividade e do Cancro, 19 October, ES Martinho Vaz de Castelo Branco, Póvoa de Santa Iria
28. C. J. A. P. Martins, A Física da Atmosfera e do Aquecimento Global, 19 October, ES Gago Coutinho, Alverca
29. C. J. A. P. Martins, A Física da Vida e dos Extraterrestres, 20 October, Colégio Vasco da Gama, Sintra
30. C. J. A. P. Martins, A Física da Atmosfera e do Aquecimento Global, 20 October, ES da Portela, Lisboa
31. C. J. A. P. Martins, A Física da Relatividade, 21 October, ES António Damásio, Lisboa
32. C. J. A. P. Martins, A Física da Gravidade e dos Satélites, 21 October, ES José Gomes Ferreira, Lisboa
33. C. J. A. P. Martins, A Física do Big Bang, 24 October, ES Josefa de Óbidos, Lisboa
34. C. J. A. P. Martins, A Física da Vida e dos Extraterrestres, 25 October, ES da Bemposta, Portimão
35. C. J. A. P. Martins, A Física da Radioactividade e do Cancro, 26 October, ES Aurélia de Sousa, Porto
36. C. J. A. P. Martins, A Física da Relatividade, 26 October, ES Clara de Resende, Porto
37. C. J. A. P. Martins, A Física da Gravidade e dos Satélites, 28 October, ES da Ribeira Grande
38. C. J. A. P. Martins, A Física da Gravidade e dos Satélites, 28 October, ES Emídio Navarro, Almada
39. C. J. A. P. Martins, A Física da Atmosfera e do Aquecimento Global, 3 November, ES da Amadora
40. C. J. A. P. Martins, A Física da Gravidade e dos Satélites, 3 November, ES António Carvalho Figueiredo, Loures
41. C. J. A. P. Martins, A Física da Gravidade e dos Satélites, 4 November, ES Afonso de Albuquerque, Guarda
42. C. J. A. P. Martins, A Física da Gravidade e dos Satélites, 4 November, ES de Pinhal de Rei, Marinha Grande
43. C. J. A. P. Martins, A Física do Big Bang, 8 November, ES Francisco Fernandes Lopes. Olhão
44. C. J. A. P. Martins, A Física da Radioactividade e do Cancro, 8 November, ES Laura Ayres, Quarteira
45. C. J. A. P. Martins, A Física do Big Bang, 9 November, ES Mouzinho da Silveira, Portalegre
46. C. J. A. P. Martins, A Física da Radioactividade e do Cancro, 10 November, ES António Granjo, Chaves
47. C. J. A. P. Martins, A Física da Gravidade e dos Satélites, 11 November, ES Júlio Martins, Chaves
48. C. J. A. P. Martins, A Física da Atmosfera e do Aquecimento Global, 14 November, ES de Mora
49. C. J. A. P. Martins, A Física da Relatividade, ES de Camilo Castelo Branco, Carnaxide, 14 November 2022
50. C. J. A. P. Martins, A Física da Radioactividade e do Cancro, ES de Santa Maria Maior, Viana do Castelo, 17 November 2022
51. C. J. A. P. Martins, A Física da Gravidade e dos Satélites, ES Inês de Castro, Vila Nova de Gaia, 17 November 2022
52. C. J. A. P. Martins, A Física do Big Bang, ES Sebastião de Gama, Setúbal, 22 November 2022
53. C. J. A. P. Martins, A Física da Gravidade e dos Satélites, Externato Cooperativo da Benedita, Alcobaça, 22 November 2022
54. C. J. A. P. Martins, A Física da Gravidade e dos Satélites, ES de Ponte de Sôr, 25 November 2022
55. C. J. A. P. Martins, A Física da Atmosfera e do Aquecimento Global, ES Amadeu Gaudêncio, Nazaré, 30 November 2022
56. C. Leote, Science communication at the IA, Messier Marathon at Observatório do Lago Alqueva, 3 April 2022

57. C. Leote, ET – A Solar System Adventure sponsored by Europlanet, Europlanet Funding session (online), 26 April 2022
58. C. Leote, Astronomy in everyday life, Monsarastro, Reguengos de Monsaraz, 3 September 2022
59. C. Pereira, Astrophotography Workshop, Sem Atrito FCUL, Lisbon, Portugal, 18 May 2022
60. C. Pereira, A Missão ARIEL e a Participação Portuguesa, XXVII Astrofesta, Sagres, Portugal, 5-7 August 2022
61. C. Pereira, Mergulhos no Oceano Cósmico, Sem Atrito FCUL, Lisbon, Portugal, 14 December 2022
62. C. Pappalardo, As galáxias e a evolução do universo, "Open day" at FCUL, 4 May 2022
63. D. F. M. Folha, A Impressão Digital dos Astros, Escola Secundária do Entroncamento, Agrupamento de Escolas do Entroncamento, online, 8 February 2022
64. D. F. M. Folha, Astrobiologia: Um Universo para explorar, ENEF 2022, Covilhã, 26 February 2022
65. D. F. M. Folha, A Impressão Digital dos Astros, Agrupamento de Escolas de Constância, via zoom, 16 March 2022
66. D. F. M. Folha, O céu não é o limite, Escola Secundária Augusto Gomes, Matosinhos, 11 October 2022
67. F. S. N. Lobo, Buracos Negros: Os lugares mais secretos do Universo", Estrelas pela Ucrânia: Evento astronómico solidário, 12 March 2022
68. F. S. N. Lobo, Space Odyssey @IA ... 2022 and beyond, Departamento de Física (FCUL), 16 March 2022
69. F. S. N. Lobo, Buracos Negros: Os lugares mais secretos do Universo", Física Fora da Academia — NFEF-FCUL, 30 Abril 2022
70. F. S. N. Lobo, Institute of Astrophysics and Space Sciences (IA): Present and Future, Encontro Ciências 2022, 16 May 2022
71. F. S. N. Lobo, Dos Buracos Negros às Ondas Gravitacionais, Dark Sky Party Alqueva 2022, 30 July 2022
72. F. S. N. Lobo, Buracos Negros: Os lugares mais secretos do Universo", 92a Feira do Livro de Lisboa, 10 September 2022
73. F. S. N. Lobo, Odisseia no Espaço: 2022 e além, Biblioteca Municipal de Vila do Porto, Santa Maria, Açores, 10 November 2022
74. F. S. N. Lobo, Buracos Negros: Novos horizontes (e física divertida com Wormholes)", "Viver a Astronomia", 17 December 2022
75. J. Brinchmann, Exoplanets, Tomter, Norway, 8 February 2022
76. J. Brinchmann, SDSS plates, Professores em Funchal, Madeira, online, 5 March 2022
77. J. Brinchmann, SDSS plates, Professores em São Miguel, Açores, online, 7 May 2022
78. J. Retrê, ESO Importance for Science Communication, Duas Décadas de Portugal no ESO (PtSpace organized event), Lisboa, 13 November 2022
79. J. Retrê, How to create a SciCom event, Sem-Atrito association workshop, Lisboa, 25 November 2022
80. L. Sousa, As três mensageiras do Universo: Luz, Partículas, e Ondas Gravitacionais, Dia Internacional das Mulheres e Raparigas na Ciência, online, 11 February 2022
81. I. A. Costa, Um dia muito especial, Escola Básica de Guetim, Espinho, 6 October 2022
82. I. A. Costa, Um dia muito especial, Colégio da Imaculada Conceição, Coimbra, 7 October 2022
83. I. A. Costa, Um dia muito especial, Escola Básica Alexandre Herculano, Lisboa, 10 October 2022
84. I. A. Costa, Um dia muito especial, Escola Básica de Pedreiras, Porto de Mós, 11 October 2022
85. I. A. Costa, Um dia muito especial, Escola Básica de São João da Foz, Porto, 12 October 2022
86. I. A. Costa, Um dia muito especial, Escola Básica Louro Artur, Almada, 17 October 2022
87. I. A. Costa, Um dia muito especial, Colégio do Oriente, Lisboa, 18 October 2022
88. I. A. Costa, Um dia muito especial, Escola Básica de Gens, Gondomar, 19 October 2022
89. I. A. Costa, Um dia muito especial, Escola Básica de Pedreiras, Porto de Mós, 20 October 2022
90. I. A. Costa, Um dia muito especial, Escola Básica de Pedreiras, Porto de Mós, 21 October 2022
91. I. A. Costa, Com a verdade me enganas, Escola Básica de Abação, Guimarães, 21 October 2022
92. I. A. Costa, Um dia muito especial, Escola Básica e Secundária de Airães, Felgueira, 24 October 2022
93. I. A. Costa, Um dia muito especial, Escola Básica de Outeiro, Gondomar, 25 October 2022
94. I. A. Costa, Um dia muito especial, Externato "Bom Jesus" , Matosinhos, 26 October 2022
95. I. A. Costa, Um dia muito especial, Escola Básica de Vila Nova de Poiares, Vila Nova de Poiares, 27 October 2022
96. I. A. Costa, Um dia muito especial, Escola Básica e Secundária de Santa Maria, Açores, 28 October 2022
97. I. A. Costa, Com a verdade me enganas, Escola Básica do Carregado, Alenquer, 28 October 2022
98. I. A. Costa, Um dia muito especial, Externato "Bom Jesus" , Matosinhos, 28 October 2022
99. I. A. Costa, Um dia muito especial, Escola Básica n.º 3 de Espinho, Espinho, 31 October 2022
100. I. A. Costa, Um dia muito especial, Escola Básica de Vouzela, Vouzela, 2 November 2022
101. I. A. Costa, Um dia muito especial, EB da Vilarinha - AE Manoel Oliveira, Porto, 3 November 2022
102. I. A. Costa, Com a verdade me enganas, Escola Básica Maria Pais Ribeiro - A Ribeirinha, Vila do Conde, 3 November 2022
103. I. A. Costa, Com a verdade me enganas, Escola Básica D. Pedro IV, Mindelo, Vila do Conde, 3 November 2022
104. I. A. Costa, Um dia muito especial, Escola Secundária de Ponte de Sor, Ponte de Sôr, 4 November 2022
105. I. A. Costa, Um dia muito especial, Escola Básica Júlio Dinis, Grijó, Vila Nova de Gaia, 7 November 2022
106. I. A. Costa, Um dia muito especial, Escola Básica de Vouzela, Vouzela, 9 November 2022
107. I. A. Costa, Com a verdade me enganas, Escola Básica e Secundária Michel Giacometti, Sesimbra, 10 November 2022
108. I. A. Costa, Um dia muito especial, Jardim do Fraldinhas, Leiria, 10 November 2022
109. I. A. Costa, Com a verdade me enganas, Escola Básica e Secundária de Miranda do Douro, Miranda do Douro, 11 November 2022
110. I. A. Costa, Com a verdade me enganas, Escola Profissional do Pico, Açores, 14 November 2022

111. I. A. Costa, Um dia muito especial, Escola Básica das Sarzedas, Castelo Branco, 14 November 2022
112. I. A. Costa, Um dia muito especial, Escola Básica de Chave, Arouca, 15 November 2022
113. I. A. Costa, Um dia muito especial, Agrupamento de Escolas Frei Heitor Pinto, Covilhã, 16 November 2022
114. I. A. Costa, Um dia muito especial, Jardim de Infância de S Caetano 2, Gondomar, 16 November 2022
115. I. A. Costa, Um dia muito especial, Escola Básica n.º 2 de São Caetano, Gondomar, 16 November 2022
116. I. A. Costa, Um dia muito especial, Externato "S. João Bosco", Porto, 17 November 2022
117. I. A. Costa, Um dia muito especial, Salesianos do Porto - Colégio, Porto, 18 November 2022
118. I. A. Costa, Um dia muito especial, Salesianos do Porto - Colégio, Porto, 19 November 2022
119. I. A. Costa, Um dia muito especial, Salesianos do Porto - Colégio, Porto, 20 November 2022
120. I. A. Costa, Um dia muito especial, Escola Básica de Atães, Gondomar, 21 November 2022
121. I. A. Costa, Um dia muito especial, Escola Básica D. Pedro IV, Sintra, 22 November 2022
122. I. A. Costa, Um dia muito especial, Escola Básica de Lagoa, Lagoa, 23 November 2022
123. I. A. Costa, Com a verdade me enganas, Escola Básica de Amareleja, Moura, 23 November 2022
124. I. A. Costa, Um dia muito especial, Escola Básica da Ponte, Porto, 24 November 2022
125. I. A. Costa, Com a verdade me enganas, Escola Básica da Agrela e Vale do Leça, Santo Tirso, 24 November 2022
126. I. A. Costa, Com a verdade me enganas, Escola Básica do Sudeste de Baião, Baião, 25 November 2022
127. I. A. Costa, Com a verdade me enganas, Escola Básica 2, 3 de Mundão, Viseu, 28 November 2022
128. I. A. Costa, Um dia muito especial, Escola Básica de Casal de Esporão, Viseu, 28 November 2022
129. I. A. Costa, Um dia muito especial, Colégio da Trofa, Trofa, 29 November 2022
130. I. A. Costa, Um dia muito especial, Escola Básica n.º 1 de Junqueira, Vila do Conde, 30 November 2022
131. I. A. Costa, Um dia muito especial, Escola Básica de Pego Longo, Sintra, 30 November 2022
132. I. A. Costa, Um dia muito especial, Escola Básica n.º 1 de Cesar, Oliveira de Azeméis, 2 December 2022
133. I. A. Costa, Com a verdade me enganas, Escola Básica Dr. Guilherme Correia de Carvalho, Seia, 5 December 2022
134. I. A. Costa, Um dia muito especial, Escola Básica Costa Cabral, Porto, 6 December 2022
135. I. A. Costa, Um dia muito especial, Escola Básica Eugénio de Andrade, Porto, 6 December 2022
136. I. A. Costa, Um dia muito especial, Externato "Ribadouro", Porto, 9 December 2022
137. I. A. Costa, Com a verdade me enganas, Escola Básica de Gafanha da Encarnação-Centro, Ílhavo, 12 December 2022
138. I. A. Costa, Um dia muito especial, Escola Básica n.º 2 de Espinho, Espinho, 13 December 2022
139. I. A. Costa, Um dia muito especial, Escola Básica de Paramos, Espinho, Espinho, 13 December 2022
140. I. A. Costa, Um dia muito especial, EB Silvalde, Silvalde, 13 December 2022
141. M. S. Cunha, LeV — Literatura em Viagem 2022 (Matosinhos), Os limites da Ciência e da Ficção; Conversa de registo informal, descontraída, com o autor Afonso Cruz, o professor Vítor Cardoso e moderação de Miguel Gonçalves; 15 May 2022
142. N. C. Santos, À procura de outras terras no Universo, em “Noites no Pátio do Museu”, Reitoria da UP, Porto, 21 July 2022
143. N. C. Santos, Conversa online sobre o Telescópio Espacial James Webb (JWST), Ciência Viva, 6 January 2022
144. J. D. F. Dias, Statistical Methods in Astrophysics AstroCamp 2022, Viana do Castelo, Portugal, 15 August 2022
145. J. P. M. de Carvalho, Da Idade da Magia a Galileu, Encontros com Ciência: A Terra no Universo e Nós na Terra, Paredes de Coura, 27 May 2022
146. J. P. M. de Carvalho, Robôs Espaciais, Colégio Flor da Linha, Paço de Arcos, 3 May 2022
147. J. P. M. de Carvalho, Da Idade da Magia a Galileu, Escola Secundária Eça de Queirós, Póvoa de Varzim, May 2022
148. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Básica de Santo Onofre, 2500-205 Caldas da Rainha, 3 October 2022
149. J. P. M. de Carvalho, Da Idade da Magia a Galileu, Colégio da Imaculada Conceição, 3510-094 VISEU, 4 October 2022
150. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, EB 4.º Conde de Ourém, 2490-529 Ourém, 6 October 2022
151. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, EB de Esporões, Rua Padre Manuel Carvalho, 4705-474 Esporões, Braga, 10 October 2022
152. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, EB+S D. Martinho Vaz de Castelo Branco, 2626-504 Póvoa Sta Iria, V.F.Xira, 11 October 2022
153. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Básica Mello Falcão, 1675-185 Pontinha, Odivelas, 12 October 2022
154. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Básica de Abação, Guimarães, 12 October 2022
155. J. P. M. de Carvalho, Da Idade da Magia a Galileu, EB Professor João de Meira, 4810-257 Guimaraes, 13 October 2022
156. J. P. M. de Carvalho, Da Idade da Magia a Galileu, EB Professor João de Meira, 4810-257 Guimaraes, 13 October 2022
157. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Secundária Raul Proença, 2500-852 Caldas da Rainha, 14 October 2022
158. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, EB da Vilarinha, Porto, 14 October 2022
159. J. P. M. de Carvalho, Da Idade da Magia a Galileu, EB+S Santos Simões, Guimarães; 4810-767 Mesão Frio, 17 October 2022
160. J. P. M. de Carvalho, Da Idade da Magia a Galileu, EB+S Santos Simões, Guimarães; 4810-767 Mesão Frio, 17 October 2022
161. J. P. M. de Carvalho, Da Idade da Magia a Galileu, EB Marquesa de Alorna,1070-095 LISBOA, 18 October 2022
162. J. P. M. de Carvalho, Da Idade da Magia a Galileu, EB Monsenhor Jerónimo do Amaral, 5000-290 Vila Real, 20 October 2022

163. J. P. M. de Carvalho, Da Idade da Magia a Galileu, EB+S D. Martinho Vaz de Castelo Branco, 2626-504 Póvoa Sta Iria, 21 October 2022
164. J. P. M. de Carvalho, Da Idade da Magia a Galileu, Colégio Machado Ruivo - Escolinha de Famalicão, V.N. de Famalicão, 21 October 2022
165. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Colégio da Imaculada Conceição, 3510-094 VISEU, 24 October 2022
166. J. P. M. de Carvalho, Um universo de informação - A Luz, Colégio Militar, 1600-498 Lisboa, 25 October 2022
167. J. P. M. de Carvalho, Um universo de informação - A Luz, EB José Sobral, 8500-132 Mexilhoeira Grande, Portimão, 26 October 2022
168. J. P. M. de Carvalho, Um universo de informação - A Luz, EB + S da Bemposta, 8500-000 Portimão, 27 October 2022
169. J. P. M. de Carvalho, Um universo de informação - A Luz, Escola Secundária Dr. José Macedo Fragateiro, 3880-307 Ovar, 28 October 2022
170. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Básica e Secundária de Airães, 4650-078 Airães, Felgueiras, 31 October 2022
171. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Agrupamento de Escolas Diogo de Macedo, Vila Nova de Gaia, 3 November 2022
172. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Básica e Secundária Santa Maria, Açores, 4 November 2022
173. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Básica e Secundária Matilde Rosa Araújo, 2785-438 Matarraque, Cascais, 7 November 2022
174. J. P. M. de Carvalho, Da Idade da Magia a Galileu, Escola Básica e Secundária Mestre Domingos Saraiva, 2725-043 Algueirão, 8 November 2022
175. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, ES Daniel Sampaio, 2815-811 Vale de Figueira, 8 November 2022
176. J. P. M. de Carvalho, Um universo de informação - A Luz, EB Dr. Carlos Pinto Ferreira, 4480-260 Junqueira, Vila do Conde, 9 November 2022
177. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Agrupamento de Escolas Diogo de Macedo, Vila November de Gaia, 10 November 2022
178. J. P. M. de Carvalho, Um universo de informação - A Luz, Escola Secundária de S. Pedro do Sul, 3660-428 S. Pedro do Sul, 11 November 2022
179. J. P. M. de Carvalho, Um universo de informação - A Luz, Escola Portuguesa de São Tomé e Príncipe, 15 November 2022
180. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Básica e Secundária de Mora, 7490-000 Mora, 15 November 2022
181. J. P. M. de Carvalho, Um universo de informação - A Luz, EB do Sudeste de Baião, Santa Marinha do Zêzere, 4640-462 Barreiro, 16 November 2022
182. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Agrupamento de Escolas Diogo de Macedo, Vila November de Gaia, 17 November 2022
183. J. P. M. de Carvalho, Da Idade da Magia a Galileu, Casa Pia de Lisboa, Lisboa, 21 November 2022
184. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Básica de Vila Boim, Elvas, 7350-501 Vila Boim, 22 November 2022
185. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Básica da Quinta de Marrocos, 1549-017 Lisboa, 22 November 202
186. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Secundária São Pedro, R. Morgado Mateus, 5000-455 Vila Real, 23 November 2022
187. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Secundária Viriato, Abraveses, 3510-204 Viseu, 28 November 2022
188. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Escola Básica D. Afonso III, 8004-014 Faro, 29 November 2022
189. J. P. M. de Carvalho, Um universo de informação - A Luz, Escola Básica e Secundária de Miranda do Douro, 5210-192 Miranda do Douro, 5 December 2022
190. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo, Agrupamento de Escolas Júdice Fialho, 8500-305 Portimão, 9 December 2022
191. J. P. M. de Carvalho, O Universo: Escalas e Conteúdo em Potências de 10, Escola Secundária de Rio Tinto, 4435-162 Rio Tinto, 13 December 2022
192. J. Afonso, O Lado Brilhante do Universo, Escola Secundária Rainha Dona Leonor - Lisboa, 24 January 2022
193. J. Afonso, A Astronomia da Próxima Geração, Escola Ciência Viva - Pavilhão do Conhecimento, 28 January 2022
194. J. Afonso, A Astronomia da Próxima Geração, evento Stars for Ukraine - Observatório Astronómico de Lisboa, 12 March 2022
195. J. Afonso, O Deslumbrante Universo Humano, Caminhadas com Arte - Monchique, 25 September 2022
196. J. Afonso, O Lado Brilhante do Universo, Festival Internacional de Ciência - Oeiras, 13 Octobe, r2022
197. J. Afonso, O Lado Brilhante do Universo, Dia Nacional da Cultura Científica - Encontro 4 Elementos (online), 24 November 2022
198. M. Cortês, Porque é que o tempo anda só para a frente?, Escola Básica, Odivelas, 31 October 2022
199. M. Cortês, Porque é que o tempo anda só para a frente?, Escola Básica Mestre Querubim Lapa, 7 November 2022
200. M. Cortês, Porque é que o tempo anda só para a frente?, Escola Vasco da Gama, Sintra, 11 November 2022
201. M. Cortês, Porque é que o tempo anda só para a frente?, Salesianos do Estoril, 21 November 2022
202. M. Cortês, Porque é que o tempo anda só para a frente?, Corroios, 30 November 2022
203. N. J. Nunes, How do we weight the Universe?, Escola Secundária José Gomes Ferreira, 11 October 2022
204. N. J. Nunes, The Autumn's sky, Escola Secundária D. Sancho II, Elvas, 12 October 2022
205. N. J. Nunes, How do we weight the Universe?, Externato de Penafirme, Santa Cruz, 18 October 2022
206. N. J. Nunes, Surfing a gravitational wave, Escola Básica e Secundária Padre Alberto Neto, 20 October 2022
207. N. J. Nunes, How do we weight the Universe?, Escola Secundária de Alcochete, 25 October 2022
208. N. J. Nunes, The Autumn's sky, Escola Básica Pedro de Santarém, Lisboa, 26 October 2022
209. N. J. Nunes, Surfing a gravitational wave, Escola Básica e Secundária de São Sebastião, Mértola, 28 October 2022

210. N. J. Nunes, Finding black holes, Escola Secundária de Palmela, 4 November 2022
211. N. J. Nunes, The Autumn's sky, Escola Básica de Amareleja, Moura, 11 November 2022
212. N. J. Nunes, The Autumn's sky, Escola Básica e Secundária Mestre Domingos Saraiva, Algueirão, Sintra, 23 November 2022
213. N. Peixinho, Beyond Pluto, there will be other worlds, Project Quark! School of Physics for Young People, Rómulo Centro Ciência Viva, Department of Physics, Coimbra 25 February 2022
214. N. Peixinho, From the Kuiper Belt to comets, Astronomy Meeting in Coruche - AstroCoruche 2022, 4 June 2022
215. N. Peixinho, The minor bodies of solar system, National Day of Science Culture 2022, University of Évora,24 November 2022
216. P. Machado, Astronomia da realidade à Ficção, ES A. Quental, Açores, 5 May 2022
217. P. Machado, A Lua observa-se daqui...!, ES Domingos Rebelo, Açores, 5 May 2022
218. P. Machado, Do Sistema Solar ao Exoplanetas, Centro Cultural Natália Correia, Açores, 5 May 2022
219. P. Machado, Espaço, a próxima fronteira, Cineteatro da Lagoa, Açores, 6 May 2022
220. P. Machado, Encontro com o Astrofisico, ES Lagoa, Açores, 6 May 2022
221. P. Machado, Encontro com o Cientista, Pavilhão do Conhecimento, Lisboa, 26 May 2022
222. P. Machado, O Sol, Amigo/Inimigo, Liga Portuguesa Contra o Cancro, Lisboa, 30 May 2022
223. P. Machado, Projecto Gaia, Galeria Miguel Nabinho, Lisboa, 31 May 2022
224. P. Machado, ES Vila do Porto, Santa Maria, Açores, 3 June 2022
225. P. Machado, Espaço: a Próxima Fronteira, Hotel Santa Maria, Açores, 3 June 2022
226. P. Machado, Encontro com o Astrofísico - Projecto "Da Terra ao Espaço", Santa Maria, Açores, 4 June 2022
227. P. Pina, Climate change in polar regions: local processes, global impacts, Escola Básica e Secundária Martim de Freitas, Coimbra, October 2022
228. P. Pina, Portuguese investigations in polar regions, Escola Básica de Vilarinho do Bairro, Anadia, March 2022
229. P. M. Sá, From the Big Bang to the formation of planets, Escola EB2,3 Dom Martim Fernandes, Albufeira, 18 January 2022
230. P. M. Sá, From the Big Bang to the formation of planets, Escola EB123 da Guia, 18 January 2022
231. P. M. Sá, The happiest thought of my life!, Escola Secundária Tomás Cabreira, Faro, 27 January 2022
232. P. M. Sá, The happiest thought of my life!, Escola Secundária de Vila Real de Santo António, 17 February 2022
233. P. M. Sá, From the Big Bang to the formation of planets, Escola Dra. Laura Ayres, Quarteira, 29 March 2022
234. P. M. Sá, From the Big Bang to the formation of planets, Escola Básica Dr. Joaquim Magalhães, Faro, 12 May 2022
235. P. M. Sá, From the Big Bang to the formation of planets, Escola Básica e Secundária da Bemposta, Portimão, 19 May 2022
236. R. C. Lima, Poluição luminosa: rejeitar uma herança do século XX/Light pollution: rejecting a 20th century heritage, Dark Sky Party Alqueva 2022, Campinho, Évora, 29 July 2022
237. S. A. G. Sousa, À descoberta de outros Mundos, MonsarAstro, OLA, September 2022
238. S. A. G. Sousa, O mundo para além da terra, Jornadas da Ciência de Arouca, Arouca, December 2022
239. T. B. Gonçalves, Os invisíveis e imparáveis neutrinos (Espaço Vai à Escola, ESERO), Escola Básica 4.º Conde de Ourém, 14 October 2022
240. T. B. Gonçalves, Os invisíveis e imparáveis neutrinos (Espaço Vai à Escola, ESERO), Escola Secundária do Arco-Íris, Portela, Loures, 20 October 2022
241. T. B. Gonçalves, Os invisíveis e imparáveis neutrinos (Espaço Vai à Escola, ESERO), Escola Secundária José Gomes Ferreira, Agrupamento de Benfica, Lisboa, 24 October 2022
242. T. Barata, Meteorologia Espacial: novo desafio global, MonsarAstro 2022, 2 September 2022
243. T. L. Campante, The music of the stars, Taibah International School, Kampala-Entebbe Rd, Uganda, 22 September 2022
244. T. L. Campante, The music of the stars, St. Mary's College Kisubi, Kisubi, Uganda, 21 September 2022
245. T. de Azevedo Silva, Lecture on the discovery of exoplanets to undergraduate/master students, VIII Jornadas de Engenharia Física, IST, Lisboa, March 2022
246. V. Adibekyan, Other Suns and other Earths in the Milky Way (in Armenian), Online, Armenia, 15 October 2022

Reports [7]

1. PLATO mission, PLATO-UOL-PDC-DD-0007, On-ground COB to Sky positions ATBD, issue1.1, 1.2, 1.3, May-July, 2021 (report)
2. E. Duarte, PLATO-UOL-PDC-DD-0006, Centers of Brightness Calculation ATBD, issue 1.0, 1.1, February-March, 2021 (report)
3. E. Duarte, PLATO-UOL-PDC-DD-0005, Star CCD position Calculation ATBD, issue 1.1, February, 2021 (report)
4. E. Duarte, PLATO-UOL-PDC-DD-0004, On-ground Attitude Estimation ATBD, issue 1.0, 1.1, 1.2, 1.3, May-November, 2021 (report)
5. E. Duarte, PLATO-UOL-PDC-TN-0001, Attitude Estimation methods, Justification Document, issue 3, 30.04.2021 (report)
6. E Duarte, PLATO-UOL-PDC-TN -0002, Centroid Determination, Justification Document, issue 6, 20.12.2021 (report)
7. Leanne P. Guy, Jean-Charles Cuillandre, Etienne Bachelet, Manda Banerji, Franz E. Bauer, Thomas Collett, Christopher J. Conselice, et al. (including, J. Brinchmann, P. Papaderos), Rubin-Euclid Derived Data Products: Initial Recommendations, Zenodo. https://doi.org/10.5281/zenodo.7195671

External seminars by IA researchers [26]

1. A. Chougule, Self-Consistent Spectral modelling of Seyfert 2 galaxies, Universidade Federal do Rio Grande do Sul (UFRGS), Brazil, 23 November 2022

2. A. R. G. Santos, Rotation and magnetic activity of solar-type stars observed by Kepler; Astrophysics Department - American Museum of Natural History - New York (NY), United States, 26 April 2022
3. A. Morozova, PCA-NN model - interim report for the PRIME project, Coimbra, 30 May 2022
4. B. Soares, Composition of terrestrial planets orbiting M dwarfs, Bern, Switzerland, 22 April 2022
5. C. J. A. P. Martins, CosmoESPRESSO: A scientific research project from alpha to Omega, Physics & Astronomy Department, U.Porto, 27 April 2022
6. C. Pappalardo, The IA effort towards MOONS: comparison between different spectral synthesis tools, MOONS Science Team meeting, Florence, Italy, 29 March 2022
7. F. S. N. Lobo, Curvature-Matter Couplings in Modified Gravity, HEP-Cosmo-Astro seminar series, 13 January 2022
8. G. Fanizza, Non-Gaussianities in the Hubble-Lemaitre diagram, Università di Pisa, Italy, 12 July 2022
9. J. Afonso, Seeking the first radio-powerful AGN within the Epoch of Reionisation, Proca Seminar Series, Online, 09 June 2022
10. J. D. F. Dias, Statistical Methods in Astrophysics AstroCamp 2022, Viana do Castelo, Portugal, 15 August 2022
11. J. C. Fonseca, Prospects for multi-wavelength Cosmology as gravity and inflation probes, Queen Mary University of London, United Kingdom, 25 March 2022
12. J. C. Fonseca, Prospects for multi-wavelength Cosmology as gravity and inflation probes, Institute of Cosmology and Gravitation, United Kingdom, 28 March 2022
13. L. Sousa, Probing cosmic (super)strings with gravitational waves, London-Oldenburg Relativity Seminars, online, Uk/Germany, 13 June 2022
14. M. Cortês, Free Will and the Arrow of Time, CNRS Centre Jean Pépin, Questions "Then and Now" Seminar Series, Paris, France, 31 March 2022
15. M. Cortês, The Arrow of Time and Free Will, Instituto de Filosofia da Nova (iFilNova), Portugal, September 2022
16. M. S. Nanda Kumar, Star cluster formation in hub-filament systems, Nagoya University, Japan, 9 December 2022
17. M. S. Nanda Kumar, Star cluster formation in hub-filament systems, National Astronomical Observatories of Japan, Mitaka, Japan, 12 December 2022
18. N. Frusciante, Can Modified Gravity challenge LCDM?, HEP-Cosmo-Astro joint seminar online series of seminars, 5 May 2022
19. N. Frusciante, Can Modified Gravity challenge LCDM?, Particle Cosmology Group, Nottingham Univ. (UK), 27 May 2022
20. N. Moedas, Atomic Diffusion and Turbulent Mixing in Solar-Like Stars: Impact on the Fundamental Properties of FG-Type Stars, Meudon, France, 4 March 2022
21. N. C. Santos, Looking for other Earths, Observatório do Valongo, Universidade Federal do Rio de Janeiro, Online, Brazil, 22 November 2022
22. N. J. Nunes, Current and future contraints on f(Q) cosmology with LCDM background, University of Heidelberg, 8 November 2022
23. S. C. C. Barros, Tidal deformation and tidal decay of WASP-103b, Rio de Janeiro, Brazil-online, LIneA SEMINARS, 9 June 2022
24. S. C. C. Barros, Frontiers of exoplanet characterisation, Birmingham, UK, 3 March 2022
25. S. C. C. Barros, Tidal deformation and tidal decay of WASP-103b, SCI-S SEMINARS - ESA, Madrid, Spain, 10 February 2022
26. V. Adibekyan, Other Suns and other Earths in the Milky Way (in Armenian), Yerevan State University, Armenia, 13 October 2022

PhD Completed [4]

1. **I. Ayuso Marazuela**, 2022, Modified gravity: from theoretical aspects to observational constraints, Supervisor(s): **J. P. Mimoso**, **F. S. N. Lobo**
2. **J. E. Silva**, 2022, Understanding physical and dynamical processes in the atmosphere of the Solar System planets with ground and space based observations, Doutoramento em Astronomia e Astrofísica (ULisboa), Supervisor(s): **P. Machado**, **M. J. P. F. G. Monteiro**
3. **J. R. C. C. C. Correia**, 2022, Coding the Cosmos: a new generation of superstring simulations, Doctoral Program in Astronomy (3rd cycle), Supervisor(s): **C. J. A. P. Martins**
4. **J. D. Camacho**, 2022, Advanced statistical data analysis methods for the detection of other Earths, Doctoral Program in Astronomy (3rd cycle), Supervisor(s): **P. T. P. Viana**, **J. P. Faria**
5. **R. P. L. Azevedo**, 2022, Cosmological Implications of Nonminimally-Coupled Gravity and the Lagrangian of Cosmic Fluids, Joint Doctoral Program in Physics MAP-fis (3rd cycle), Supervisor(s): **P. P. Avelino**

MSc Projects Completed [14]

1. A. W. Neitzel, 2022, Determination of age and mass for seismic star in the Ariel input catalog, Master in Astronomy, Supervisor(s): **D. Bossini**, **T. L. Campante**
2. A. A. Dias, 2022, Better Science Through an Enhanced User Interface with the ALMA Archive, Master in Informatics Engineering (Software Engineering), Supervisors: Sara Alexandra Cordeiro Madeira, **Israel Matute**
3. C. M. J. Marques, 2022, Optimization of Spectroscopic Tests of Fundamental Physics: from ESPRESSO to the ELT, Master in Physics Engineering (FCT NOVA), Supervisor(s): **C. J. A. P. Martins**
4. 4. D. Quirino, 2022, Modelling Venus-like exoplanetary atmospheres with a GCM: planetary parameters impact on the large-scale circulation and observational prospects, Supervisor(s): G. Gilli, **P. Machado**
5. G. Roque, 2022, Development of a metrology tool for the alignment of optical systems, Master in Physics Engineering (FCUL), Supervisor(s): **A. Cabral**
6. J. A. B. Dias, 2022, Detection and limits of detection of minor chemical species in Solar System's atmospheres, Supervisor(s): **P. Machado**
7. J. V. Gomes, 2022, Energetic Causal Sets in 2+1d, Master thesis, University of Coimbra, Supervisor(s): **A. R. Liddle, M. Cortês**

8. L. Atayde, 2022, Phenomenology and cosmological constraints on f(Q)-gravity, Master in Physics (FCUL),Supervisors: **N. Frusciante**
9. M. Santiago, 2022, Evolution and dynamics of solar H-alpha filaments and their relation with Space Weather events, Master in Astrophysics and Instrumentation for Space, University of Coimbra, Supervisors: **R. Gafeira**
10. N. A. R. Carvalho, 2022, Towards a Universal Machine Learning Pipeline to Understand Galaxies, Master in Astronomy, Supervisor(s): **A. Humphrey**
11. P. M. N. M. G. Martins, 2022, O ambiente de novos enxames estelares jovens na Galáxia exterior: um estudo no milímetro e no infravermelho, Supervisor(s): **J. Lin Yun**
12. R. P. Alegria, 2022, Implementation of a Michelson Interferometer for Length Metrology, Master in Physics Engineering (FCUL), Supervisor(s): **A. Cabral**
13. R. P. Silva, 2022, Impact of wiggliness on the cosmic microwave background anisotropies generated by cosmic string networks, Physics Master, Supervisor(s): **L. Sousa**, **I. Yu. Rybak**
14. S. N. F. Nobrega, 2022, New numerical approaches to galaxy cluster simulations in non-homogeneous LTB models, Supervisor(s): **A. da Silva**

BSc Traineeships / Projects completed [122]

(under the supervision of IA researchers)

1. Abhisek Sarkar, Black hole shadows and photon rings, IAstro Summer Internships, Jul 2022
2. Aditi Das, Automatic classification of galaxies using the Galaxy Zoo data and supervised learning, IAstro Summer Internships, Jul 2022
3. Aditya Swamy, Local vs. global physical properties of galaxies, IAstro Summer Internships, Jul 2022
4. Adrian Cabral, Astrophysical tests of fundamental physics, Programa de Estágios Extra-Curriculares da FCUP (PEEC), Feb - Sep 2022
5. Afonso Vale, How fast do galaxies grow?, IAstro Summer Internships, Jul 2022
6. Alexandre Monforte, alfa=1/137, Laboratório de Astrofísica (FCUL), Oct 2021 - Feb 2022
7. Alice Reis, How fast do galaxies grow?, IAstro Summer Internships, Jul 2022
8. Allan A. L. Ferreira (São Paulo State University), Inpainting techniques to reconstruct partially detected cartographic features, internship at Univ. Coimbra, Jan - Apr 2022
9. Aman Dubey, Black hole shadows and photon rings, IAstro Summer Internships, Jul 2022
10. Amresh Verma, Exploring the impact of modifications of gravity law on cosmological observables, IAstro Summer Internships, Jul 2022
11. Ana Beatriz Moreira, Light my MOSFIRE, Oct 2021 - Jan 2022
12. Ana Mafalda Vieira (Colégio R.S. Isabel, Coimbra - OCJF), Low redshift constraints on modified gravity models, Junior internships, 2022
13. Aniket Prasad, On the origins of super-Mercuries, IAstro Summer Internships, Jul 2022
14. Anish Kalsi, Testing the Universe's acceleration law, IAstro Summer Internships, Jul 2022
15. Anselmo Falorca, Probing sdB stars, March 2022 - July 2022
16. António Miguel Correia, Measuring the size of exoplanets with CHEOPS, Programa de Estágios Extra-Curriculares da FCUP (PEEC), February - July 2022
17. Anup Karekar, Light my MOSFIRE, IAstro Summer Internships, Jul 2022
18. Anushka Tilekar, Is there Gravity beyond Einstein?, IAstro Summer Internships, Jul 2022
19. Ardra K P, The Cosmic Microwave Background radiation: a phenomenological study, IAstro Summer Internships, Jul 2022
20. Arihant Tiwari, Using deep learning to estimate the bulge-to-total light ratio of galaxies, IAstro Summer Internships, Jul 2022
21. Arpitha PV, Passive, but not resigned, IAstro Summer Internships, Jul 2022
22. Ashesh Khatua, Automatic classification of galaxies using the Galaxy Zoo data and supervised learning, IAstro Summer Internships, Jul 2022
23. Atharva Zend, Local vs. global physical properties of galaxies, IAstro Summer Internships, Jul 2022
24. Barbara Ferreira, Light my MOSFIRE, Feb - Mar 2022
25. Bárbara Oliveira, Measuring the size of exoplanets with CHEOPS, Programa de Estágios Extra-Curriculares da FCUP (PEEC), February - July 2022
26. Beatriz Resendes, Identifying and Characterizing AGN in next-generation radio surveys with machine learning, project for the Laboratório em Astronomia e Astrofísica (FCUL), Sep 2021 - Feb 2022
27. Blanca Gilabert (JiC): Forecasting Redshift Drift Cosmography with ELT Measurements, Junior internships, 2022
28. Carlos António, Can the Ti I 5713.9 and Fe II 6149.2 A spectral lines be used to follow RV activity noise?, IAstro Summer Internships, July 2022
29. Catarina Mendes, From the 2-D to N-D, an AGN selection using unsupervised learning, curricular internship (Univ. Nova de Lisboa), Programa de Introdução à Investigação Científica (PIIC), Feb - Apr 2022
30. Cheila Nila Bhurahal, Characterization of hot solartype stars with exoplanets, Programa de Estágios Extra-Curriculares da FCUP (PEEC), Feb - Jul 2022
31. Clara Prats (JiC): Forecasting constraints on the stability of alpha at multiple redshifts, Junior internships, 2022
32. Cristian Salazar Albarrán, Is there Gravity beyond Einstein?, IAstro Summer Internships, Jul 2022
33. Daniel Matos, Light my MOSFIRE, Feb - Mar 2022
34. Daniela Lopes, Time Domain Astronomy: redshift drifts as a probe of Cosmology Following and characterising redshift space distortions, Oct 2021 - Feb 2022
35. Daniela Teófilo Branco, Time Domain Astronomy: redshift drifts as a probe of Cosmology, Laboratório de Astrofísica (FCUL), Oct 2021 - Feb 2022
36. David Pereira, Cosmological probes of dark energy, Laboratory of Astronomy, Oct 2021 - Jan 2022

37. Dhwani Singh, Wormholes in spacetime and their use for interstellar travel: A tool for teaching general relativity, IAstro Summer Internships, Jul 2022
38. Duarte Branco, Can galaxy clusters reveal the local curvature and fractal dimension of the Universe?, Laboratório de Astrofísica (FCUL), Oct 2021 - Feb 2022
39. Duarte Branco, Do the chemical mixtures of rocky planets reflect the initial composition of the planet-forming disk?, IAstro Summer Internships, Jul 2022
40. Duarte Feiteira, Wormholes in spacetime and their use for interstellar travel: A tool for teaching general relativity, IAstro Summer Internships, Jul 2022
41. Edson Jequecene, Contributions to research in astronomy teaching and communication, IAstro Summer Internships, Jul 2022
42. Edson Jequecene, Contributos para a investigação em ensino e divulgação das ciências - Avaliação da formação contínua de professores - I, IAstro Summer Internships, Jul 2022
43. Eduardo A. Magalhães, Contributos para a investigação em ensino e divulgação das ciências - Conhecimentos em Astronomia, Programa de Estágios Extra-Curriculares da FCUP (PEEC), Jan - Jul 2022
44. Eduardo S. Nascimento (São Paulo State University), Automatic extraction of cartographic features from remotely sensed imagery, internship at Univ. Coimbra, Jan - Apr 2022
45. Emilia Dorfel, The Universe at everyone's reach, IAstro Summer Internships, Jul 2022
46. Filipa Almeida, Contributions to research in astronomy teaching and communication, IAstro Summer Internships, Jul 2022
47. Gabriel Róis, Cosmological Tests: How to know the evolution of the Universe?, IAstro Summer Internships, Jul 2022
48. Gorka Zubiri, Fontes estelares jovens vistas no infravermelho próximo e no milímetro, Sep - Dec 2022
49. Henrique Esgalhado, Matter over time, Oct 2021 - Feb 2022
50. Inês Heitor, Passive, but not resigned, IAstro Summer Internships, Jul 2022
51. Inês Rolo Martins, The enigma of Li-rich giants and its relation with stellar activity, Programa de Estágios Extra-Curriculares da FCUP (PEEC), Feb - Jul 2022
52. Isadora Monteiro, Contributions to research in astronomy teaching and communication, IAstro Summer Internships, Jul 2022
53. Jabulane Carnete, Contributions to research in astronomy teaching and communication, IAstro Summer Internships, Jul 2022
54. Jarno Sandrin, Automatic classification of galaxies using the Galaxy Zoo data and supervised learning, IAstro Summer Internships, Jul 2022
55. Joana Bagagem, Connecting galaxies photometry with Super-Massive Black Hole (SMBH) properties: A machine learning approach, a project for the Laboratório em Astronomia e Astrofísica (FCUL), Sep 2021 - Feb 2022
56. João Chaves, Exploring the impact of modifications of gravity law on cosmological observables, IAstro Summer Internships, Jul 2022
57. João Cunha, Black hole shadows and photon rings, IAstro Summer Internships, Jul 2022
58. João Custódio, Pulsations of red-giant stars, Programa de Estágios Extra-Curriculares da FCUP (PEEC), February - July 2022
59. João Custódio, Wormholes in spacetime and their use for interstellar travel: A tool for teaching general relativity, IAstro Summer Internships, Jul 2022
60. João Pedro Pais, Development of Fast and Accurate Emulators of Galaxy Cluster Properties Using (ML) Machine Learning Algorithms and Cosmological Simulations, Laboratório de Astrofísica (FCUL), Oct 2021 - Feb 2022
61. João Pessoa, Pulsations of red-giant stars, Programa de Estágios Extra-Curriculares da FCUP (PEEC), February - July 2022
62. João Santos, AGN demographics through ATHENA simulations, a project for the Laboratório em Astronomia e Astrofísica (FCUL), Sep 2021 - Feb 2022
63. Jorge Lopes, Redshift drift 2nd derivatives for SKAO, FCUP Project in Astrophysics, Mar-Jun 2022
64. José Lopes, Modelling Active Galactic Nuclei with Machine Learning", a project for the Laboratório em Astronomia e Astrofísica (FCUL), Sep 2021 - Feb 2022
65. José Marques, Todos os caminhos levam ao Espaço, internship in Science Communication, Nov 2021 - Jan 2022
66. Juliana Amaral, Probing the Interior of sdB stars with asteroseismology, September 2022 - December 2022
67. Kamalpreet Kaur, The Cosmic Microwave Background radiation: a phenomenological study, IAstro Summer Internships, Jul 2022
68. Kilian Srowlik, Calculating the black hole mass using the TAP equation, Astrophysics Lab, Oct 2021 - Jan 2022
69. Laurinda Macaringue, Giant Hub-Filament Systems, IAstro Summer Internships, Jul 2022
70. Leonor Ferro, Secrets of the most massive supermassive black holes in the Universe, a project for the Laboratório em Astronomia e Astrofísica (FCUL), Sep 2021 - Feb 2022
71. Lívia Moura, Domain Walls' evolution studied by network simulations, Junior internships, 2022
72. Lucas Batista, Public Engagement with Science - "The Universe at everyone's reach", IAstro Summer Internships, July 2022
73. Ludving Cano, How fast do galaxies grow?, IAstro Summer Internships, Jul 2022
74. Luis Leitão, Light my MOSFIRE, Feb - Mar 2022
75. Mª Margarida Lima, Cosmological Tests: How to know the evolution of the Universe?, IAstro Summer Internships, Jul 2022
76. Madalena Oliveira, Wormholes in spacetime and their use for interstellar travel: A tool for teaching general relativity, IAstro Summer Internships, Jul 2022
77. Mafalda Assis, Local vs. global physical properties of galaxies, IAstro Summer Internships, Jul 2022
78. Margarida Barros de Oliveira, Studying the atmospheres of other worlds within the Solar System, IAstro Summer Internships, Jul 2022
79. Margarida Oliveira, Studying the atmospheres of other worlds within the Solar System, IAstro Summer Internships, Jul 2022
80. Maria Antónia Cravinho, AGN demographics through ATHENA simulations, a project for the Laboratório em Astronomia e Astrofísica (FCUL), Sep 2021 - Feb 2022
81. Maria Colaço, Black hole shadows and photon rings, IAstro Summer Internships, Jul 2022
82. Maria Margarida Lima, Cosmological Tests: How to know the evolution of the Universe?, IAstro Summer Internships, Jul 2022

83. Maria Vaz de Salvador, Contributos para a investigação em ensino e divulgação das ciências - Atitutes e Crenças em relação à Astronomia, Programa de Estágios Extra-Curriculares da FCUP (PEEC), Jan - Jul 2022
84. Mariana Gomes, The Universe at everyone's reach, IAstro Summer Internships, Jul 2022
85. Mariana Navia, Do the chemical mixtures of rocky planets reflect the initial composition of the planet-forming disk?, IAstro Summer Internships, Jul 2022
86. Mariana Rodrigues, Testing the Universe's acceleration law, IAstro Summer Internships, Jul 2022
87. Mário Neto, Cosmological Tests: How to know the evolution of the Universe?, IAstro Summer Internships, Jul 2022
88. Matilde Abreu, Do the chemical mixtures of rocky planets reflect the initial composition of the planet-forming disk?, IAstro Summer Internships, Jul 2022
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95. Pedro Tavares, Exploring the impact of modifications of gravity law on cosmological observables, IAstro Summer Internships, Jul 2022
96. Rafael Paiva, Comunicação de Ciência nas Redes Sociais: Caracterização e estratégia do Instituto de Astrofísica e Ciências do Espaço, internship of MSc students in Science Communication, Oct 2022 - Dec 2022
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114. Tarek Haimuri, Public Engagement with Science - "The Universe at everyone's reach", IAstro Summer Internships, July 2022
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120. Victor Santos, Passive but not resigned, Feb - Mar 2022
121. Yuri Carrilho Damasceno, Characterization of hot solartype stars with exoplanets, Programa de Estágios Extra-Curriculares da FCUP (PEEC), Feb - Jul 2022
122. Yuri Carrilho Damasceno, Probing the Interior of sdB stars with asteroseismology, September 2022 - December 2022

COVER PICTURE: NIRPS instrument with adaptive optics system. The component in the centre is the ADC, whose design, construction and testing was done by the IA. © N. Blind (Observatoire de Genève)/INIRPS/ESO consortium)

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